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Proposed Sludge Management Program for the Los Angeles/Orange County Metropolitan Area Appendices

Los Angeles-Orange County Metropolitan
Area Project, Whittier, CA

Prepared for

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San Francisco, CA

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APPENDICES

PROPOSED SLUDGE MANAGEMENT PROGRAM FOR THE LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

EIS/EIR DRAFT

ENVIRONMENTAL IMPACT STATEMENT
ENVIRONMENTAL IMPACT REPORT

LA/OMA PROJECT
EPA
United States
Environmental Protection
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The Draft Environmental Impact Statement/Environmental Impact Report (DEIS/DEIR) and Facilities Plan evaluates the Proposed Sludge Management Program for the Los Angeles/Orange County Metropolitan Area. The Proposed Program was designed for environmentally, socially and economically cost-effective recovery of resources from wastewater sludges and reliable management of wastewater sludge to minimize the public health risks and environmental degradation. The Proposed Program is divided into three separate entities, which would provide for sludge management in the Los Angeles County Sanitation Districts, Orange County Sanitation Districts, and the City of Los Angeles.

This is the Appendices to the Report.

17. Document Analysis a. Descriptors

Sludge treatment
Sludge disposal
Ultimate disposal
Resource recovery

b. Identifiers/Open-Ended Terms

Environmental impact statement
Los Angeles County CA
Orange County CA
LA/OMA Project

c. COSATI Field/Group

18. Availability Statement

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REGULATORY COMPATIBILITY OF PROPOSED FACILITIES

This appendix describes the results of a review of the compatibility of facilities proposed for construction during Phase II with applicable regulatory requirements. A review of applicable regulations and permits is provided in Reference No. 1. Discussion in this appendix focuses on those permits or regulations which are of major importance to implementation of the proposed Phase II facilities. An overview of the potential permit requirements is also provided.

LANDFILL DISPOSAL

The State Water Resources Control Board guidelines (Ref. 2) for waste disposal to land recommend that high moisture content wastes (greater than 50 percent moisture) not be disposed with Group 2 materials at sites without either natural or artificial leachate control facilities. Puente Hills landfill is the only site proposed to receive dewatered cake during Phase II. An artificial leachate control facility is included as part of the Phase II facilities. Therefore, compliance with the State guideline is anticipated.

The Regional Water Quality Control Board - Los Angeles Region has indicated that moisture addition should not exceed 25 gallons per cubic yard at the Puente Hills site (Ref. 3). Assuming a maximum sludge loading of 150 dtpd at 22.5 percent solids, and a present landfill loading of 6000 tpd at 600 lb/yd^3, a moisture addition of about 6 gal/yd^3 would result. Current waste discharge requirements permit disposal of Group 2 liquid waste at a rate of 10 gallons per cubic yard. If this is added to that expected from sludge the total is still well within the recommended limit. Furthermore, during Phase II, solid waste loading at Puente Hills is expected to increase substantially (10,000 tpd est.) upon closure of Palos Verdes and operating industries landfills. It should be noted that attainment of this moisture loading guideline does not remove the requirement for a leachate control system.

Some composted product may be landfilled during Phase II if the material can not be marketed for any reason. Compost is generally greater than 50 percent solids content and should pose no difficulties in landfilling with other Group 2 wastes.

The Regional Water Quality Control Board - Santa Ana Region has required that sludges be at least 50 percent solids content prior to disposal with Group 2 wastes at landfill sites within the Board's jurisdiction. Material produced from the Round Canyon processing site is expected to be greater than 50 percent solids and compliance with the Board's policy is anticipated.

State Water Resources Control Board guidelines (Ref. 2) specify community incinerator ash as a Group 1 waste requiring disposal in a Class I landfill site. If char/ash from thermal processing is considered a Group 1 waste, a special permit may be required for disposal to a Class II-1 landfill. If such a permit cannot be obtained, char/ash would require disposal at a Class I facility. BKK and Calabasas landfills are the most likely Class I facilities for long term disposal.

COMPOST MARKETING

Guidelines on use of sludge based compost in bagged products or bulk sale and giveaway programs are yet to be promulgated by EPA under Section 405 of the Clean Water Act. These guidelines are expected to address both the trace metal and trace organic content of the sludges as well as requirements for pathogen quality. Since the guidelines are yet to be published, no statement regarding compliance is possible at this time. If local sludge based compost materials cannot comply with the guidelines, such material would have to be landfilled with other Group 2 wastes. Therefore, violation of any future guidelines on use of compost product is not expected as long as landfill disposal of composted sludge remains available.

It should be noted that compost produced from OCSD sludges is not recommended for distribution at this time, even in the absence of official guidelines. Heavy metal contents are quite high and generally above levels being informally considered as part of Section 405 regulations. Until such time as industrial pretreatment can reduce the heavy metal content or until Section 405 guidelines are promulgated, it is not proposed that OCSD sludges be marketed.

AIR QUALITY REGULATIONS

The Phase II facilities were reviewed as to compliance with U.S. EPA's promulgated New Source Performance Standards (NSPS) and applicable new source review requirements. New Source Performance Standards limit emissions from sludge incineration to the following: particulates, 1.30 lb/dry ton of sludge input; opacity, 20 percent; beryllium, 10 gm/24 hours; mercury, 3200 gm/24 hours. The Phase II facilities are projected to produce particulate emissions at a rate of about 0.45 lb/dry ton with an opacity considerably less than 20 percent.

Mercury concentrations for the CLA under Phase II marine secondary conditions are projected to be about 13 mg/kg. With a sludge load of 264 dtpd, the mass input rate to the furnace would be 3120 gm/day. Corresponding values for LACSD are about 5 mg/kg, a sludge load of 238 dtpd, and a mass input rate of 1080 gm/day. Most of the input mercury should volatize at temperature conditions maintained in the thermal reactor. Some of the volatilized mercury will be removed during wet scrubbing of the flue gas. The removal rate of mercury through scrubbers installed on an incinerator at Livermore, California was found to be about 90 percent (Ref. 4) and a value of 60 percent was used in the Boston EIS (Ref. 5). Assuming a 60 percent removal the mass emission rate from the furnace would be about 1250 gm/day for the CLA and 430 gm/day for LACSD.

There is a lack of operational data on the mass emission rate of beryllium for sludge incineration systems. It has been shown that most of the beryllium in coal fuel power plants remains in the ash which is consistent with the measured boiling points for beryllium and its compounds. Furthermore, available data on LA/OMA sludge characteristics indicated that beryllium is present at less than detectable levels.

Based on the above analysis it is projected that all applicable NSPS will be achieved by the proposed Phase II facilities.

The Phase II facilities will be required to comply with new source review requirements since the South Coast Air Basin is a designated non-attainment area for ozone, carbon monoxide, nitrogen dioxide, and primary particulates. Compliance with new source review will be determined by comparison with Regulation XIII adopted by the South Coast Air Quality Management District (SCAQMD) on October 5, 1979, and as amended by the State Air Resources Board (ARB) on October 23, 1979. The provisions of this reglation apply to any new or modified stationary source which results in a net increase of any air contaminant greater than 150 lbs/day except carbon monoxide for which the increase is 750 lbs/day (Rule 1302.a). Affected sources shall offset all emission increases of all affected air contaminants times an offset factor (Rule 1307.a). The latter has a value of 1.0 to 1.2 depending on whether the facility is a modification to an existing permit unit or a new permit unit and providing the compensating emission reductions are within 5 miles of the source.

Direct project emissions include all stationary sources and in-plant mobile sources, but exclude mobile emissions from off-site sludge hauling to a landfill (Rule 1302.q, 1306.d.2). Phase II emissions should be at least partially offset by the 1978 base condition. Rule 1306.a.1 requires that emissions be accumulated from October 8, 1976, or within the last five years, whichever time period is shorter. However, existing emissions at the treatment plants have not changed significantly in recent years and the base conditions would not change significantly if averaged over a longer time period. Phase II emissions have been calculated using the maximum rated capacity as required by Rule 1306.c.1.

The Phase II facilities will produce fuels and electrical energy which will be used to satisfy power demands required for both sludge processing and upgraded levels of wastewater treatment. Both sludge processing and improved wastewater treatment are required under provisions of the Clean Water Act. Therefore, these new power demands will occur regardless of whether energy is recovered during sludge processing or not. If energy is not recovered the demands will be met by power utilities, resulting in increased levels of air emissions from local generating plants. Recovery of energy during sludge processing can be viewed, therefore, as an energy conservation measure since fossil fuels will be conserved at local electrical utilities. Rule 1308 allows offsets for emission reductions which result from energy conservation. Therefore, Phase II emissions may be offset by emissions from steam-electric power generation using fuel oil to produce an equivalent amount of net power.

Reasonable planning case emissions were used in the analysis for HC, CO, and particulates since it is believed that such levels can be reliably achieved in practice. However, reasonable worst case conditions for the thermal reactor were examined for the pollutants SO_X and NO_X. Descriptions of air emission scenarios and planning and worst case assumptions are provided in Chapter II of the environmental impact statement for each operating agency. An emission inventory for the CLA Phase II facilities (assuming H_2S removal from digester gas or equivalent in-plant reductions of SO_2 emissions) is shown in Table 1 for the cases of Full and Partial CCP.

With Full CCP, large emission reductions are shown for hydrocarbons and NO_x, and somewhat smaller reductions for CO, SO_x, and TSP. If the reasonable worst case conditions for SO_x and NO_x are considered, large emission reductions for NO_x are still realized, but a small increase in SO_x is shown. The increase in SO_x should be less than 150 lb/day.

Under the Partial CCP scenario, emission reductions for HC and NO_x are also projected but the reductions are not as large as for the full CCP case. Slight decreases in CO and TSP are predicted. Under the reasonable worst case conditions an emission reduction for NO_x is shown along with a slight increase in SO_x.

A net increase greater than 150 lb/day is not expected for any pollutant under either the Full CCP or Partial CCP cases. Therefore, it is concluded that Phase II facilities at Hyperion should comply with New Source Review Regulation XIII, subject to the interpretation of said regulations as described above and assuming H_2S removal from digester gas or equivalent in-plant reductions of SO_x emissions. The equivalent electrical power emissions were judged ineligible as an emission offset, the new source review threshold requirements would continue to be met for all pollutants, except SO_x for which an increase greater than 150 lb/day is projected in which case additional emission offsets or additional in-plant SO_2 reductions may be required.

An emissions inventory for the LACSD Phase II facilities (assuming H_2S removal from digester gas or equivalent in-plant reductions of SO_2 emissions) is shown in Table 2. It is assumed that all three thermal processing modules are operating since this is a possible mode of operation during winter months. Significant emission reductions (from 1978 levels) for HC and NO_x are projected, and smaller reduction in SO_x and TSP. CO is shown to increase, but the increase is substantially less than 750 lb/day. Therefore, it is concluded that Phase II facilities at JWPCP should comply with New Source Review Regulation XIII, subject to the interpretation of said regulation as described above and assuming H_2S removal from digester gas or equivalent in-plant reductions of SO_x emissions. If the equivalent electrical power emissions were judged ineligible as an emission offset, new source review requirements would continue to be met for all pollutants, except SO_x for which an increase greater than 150 lb/day is projected in which case additional emission offsets or additional SO_2 reductions may be required. The particulate increase is close to 150 lb/day, but reductions in HC and NO_x could be used to further offset TSP increases according to Rule 1308.d.

The emission inventory for OCSD Phase II facilities is shown in Table 3. Projected emissions for continued use of IC engines are not shown. For purposes of new source review, it is assumed that all digester gas would be used in facilities for which operating permits have been granted and that no modification of these facilities would be required. Emissions from the compost operation at Round Canyon have been separated from those of the JPL/ACTS process. Since the JPL/ACTS demonstration does not depend on or affect the operation at Round Canyon, it is assumed to not be part of the same stationary source (Rule 1302.q).

TABLE 1

CLA PHASE II FACILITIES - COMPLIANCE WITH NEW SOURCE REVIEW REQUIREMENTS
REASONABLE PLANNING CASE CONDITIONS(c)

	EMISSIONS, LB/DAY (a)				
	HC AS CH_4	CO AS CO	SO_x AS SO_2	NO_x AS NO_2	TSP
Full CCP					
Direct Emissions(b)	110	385	485 (885)(c)	1100 (2015)	160
Electrical Offsets	45	50	650	550	100
1978 Base(d)	1935	595	220	4705	125
Net increase (+) or decrease (-)	-1870	-260	-385 (+15)	-4155 (-3240)	-65
Net increase (+) or decrease (-) (No elec. offset)	-1825	-210	+265 (+665)	-3605 (-2690)	+35
Partial CCP					
Direct Emissions(b)	1160	620	485 (885)	3475 (4395)	215
Electrical Offsets	45	50	650	550	100
1978 Base (d)	1935	595	220	4705	125
Net increase (+) or decrease (-)	-820	-25	-385 (+15)	-1780 (-860)	(-10)
Net increase (+) or decrease (-) (No elec. offset)	-775	+25	+265 (+665)	-1230 (-310)	+90

(a) All values rounded up to nearest 5 lb/day.

(b) Includes all stationary sources, but excludes mobile emissions from char/ash hauling.

(c) Values in parenthesis are for the reasonable worst case conditions applied to the thermal processing system only.

(d) Includes only the emissions from onsite operation of internal combustion engines and boilers. A portion of the digester gas is used offsite at the adjacent Scattergood Steam Plant. Emissions from offsite use of digester gas were not included in the 1978 Base inventory to assure that the analysis would be conservative. Inclusion of such emissions would have the effect of increasing the 1978 Base Level.

TABLE 2

LACSD PHASE II FACILITIES - COMPLIANCE WITH NEW SOURCE REVIEW REQUIREMENTS REASONABLE PLANNING CASE CONDITIONS (c)

375 dtpd to Thermal Processing

	EMISSIONS, LB/DAY (a)				
	HC AS CH_4	CO AS CO	SO_x AS SO_2	NO_x AS NO_2	TSP
Direct Emissions (b)	815	835	580 (1105) (c)	3255 (4465)	265
Electrical Offsets	65	75	985	835	145
1978 Base (d)	1935	605	90	4765	135
Net increase (+) or decrease (-).	-1180	+215	-490 (+30)	-2300 (-1135)	-10
Net increase (+) or decrease (-) (No elec. offsets)	-1115	+290	+495 (+1015)	-1465 (-300)	+135

(a) All values rounded up to nearest 5 lb/day.

(b) Includes all stationary sources and on-site mobile sources, but excludes mobile emissions from wet cake and char/ash hauling to landfill.

(c) Values in parenthesis are for the reasonable worst case conditions applied to the thermal processing system only.

(d) Includes only those emissions from onsite operation of IC engines and boilers. A portion of the digester gas is used offsite by an adjacent oil refinery. Emissions from offsite use of digester gas were not included in the 1978 Base inventory to assure that the analysis would be conservative. Inclusion of such emissions would have the effect of increasing the 1978 Base Level.

TABLE 3

OCSD PHASE II FACILITIES - COMPLIANCE WITH NEW SOURCE REVIEW REQUIREMENTS
REASONABLE PLANNING CASE CONDITIONS (b)

	EMISSIONS, LB/DAY (a)				
	HC AS CH_4	CO AS CO	SO_x AS SO_2	NO_x AS NO_2	TSP
Compost/Air Dry at Round Canyon	41	260	31	196	22
JPL/ACT Demonstration	2	3	36 (215)(b)	21 (207)	11

(a) Includes all stationary sources and on-site mobile sources, but excludes mobile emissions from wet cake transport to Round Canyon and compost hauling to a landfill.

(b) Values in parenthesis are for the reasonable worst case conditions applied to the thermal processing system only.

The Round Canyon facility should meet new source review requirements for all pollutants except NO_x for which an increase slightly above 150 lb/day is projected. All emission at Round Canyon would result from on-site operation of mobile equipment. The emissions at the Round Canyon site are considerably higher than other mobile emissions, including those from wet cake hauling. This prompted a review of design criteria developed for the windrow composting operation. A rather high rate of fuel consumption was assumed in order to provide a conservative estimate of energy use. Revised estimates indicate that fuel consumption can likely be reduced below present estimates and that NO_x should be below 150 lb/day. If this cannot be achieved, possible emission offsets include: (1) additional emission control devices or modifications on the mobile sources at Round Canyon to reduce the air emission factor; and (2) emission reductions from stationary sources at either Plant No. 1 and 2. Therefore, it is concluded that Phase II facilities for OCSD at Round Canyon would appear to comply with New Source Review Regulation XIII, subject to the interpretation of said regulation as described above, and subject to possible attainment of additional offsets for NO_x emissions.

The JPL/ACTS demonstration would appear to comply with all new source review requirements under the reasonable design case. Under the reasonable worst case assumptions, mass emission rates for NO_x and SO_x are projected to exceed 150 lb/day. In this case, emission offsets would be required to comply with Regulation XIII. Sufficient offsets are projected to be available within the treatment plant.

It should be noted that exemptions from requirements of Regulation XIII are available for resource conservation and energy projects under certain conditions (Rule 1304.e). The conditions under which an exemption can be granted are rather complex, but do apply to cogeneration projects using biomass-derived fuels for useful energy generation. It is necessary that the applicant establish by modelling that the new source will not cause a new violation or make measurably worse an existing violation of any national ambient standard at the point of maximum ground level impact. Results of air dispersion modelling indicated that the DFTP and CCP would result in rather small incremental increases in the maximum ground level concentration. Predicted ground level concentrations are generally less than 10 percent of the most stringent ambient air standard, except for NO_x where the increase is about 20 to 30 percent. Whether proposed Phase II facilities would qualify for an exemption is not known at this time.

It should be kept in mind that the foregoing evaluation has not considered detailed design of emission control systems but is based upon planning information. Final determination of regulatory compliance rests with the respective regulatory agencies and will be based upon the facts available at the time of permit application. More detailed design information, better estimates of baseline emissions, interpollutant offsets, are among the factors which affect the foregoing conclusions. Additionally, the South Coast Air Basin, is not designated a nonattainment area for SO_2. However, since a fraction of the SO_2 emission is a precursor of particulates, some offset requirements may be specified for SO_2. The present analysis was unable to consider this potential due to lack of information regarding interpollutant tradeoff requirements. The analysis may be somewhat conservation with respect to SO_2 emissions. Thus, the foregoing evaluation should not be viewed as the final determination of regulatory compatibility and is subject to the development of new information.

Besides the New Source Performance Standards and the New Source Review, there are also general prohibitions under Regulation IV of the AQMD. Emissions from the CCP and DFTP for CLA and LACSD were examined for compliance with the Prohibitions. Results of the evaluation are presented in Table 4. It should be noted that this assessment was conducted by LA/OMA for planning purposes and was based on interpretation of AWMD regulations. It does not imply an assessment by AQMD for permitting purposes.

For particulate matter (TSP), prohibitions under Rules 404, 405, 409, 475a(3) and 476a(2) would apply. In general, the most stringent mass discharge limit is 11 lb/hr of TSP as defined in Rule 475 and 476. It would be applicable to both the CCP and DFTP, but it would be met by both units with a comfortable margin. The most stringent concentration limit is 0.01 gr/SCF (dry) as defined in rule 476. The CCP would be able to meet the limit, but the DFTP would not. However, Rule 476 further states that there is no violation unless both the mass and concentration limits for TSP are exceeded together. Therefore, the DFTP would still comply with the Rule through meeting the mass limit. The TSP concentration limits in Rule 404 and 409 are much less stringent and the DFTP would meet them with a safe margin.

A concentration limit for carbon monoxide of 2000 ppm is defined in Rule 407. This limit can be met by both the CCP and DFTP with a wide margin.

The sulfur content of gaseous fuel is limited by Rule 431.1. However, digester gas is explicitly exempted from the Rule.

Rules 474, 475a(1),(2), 475.1 and 476a(1) apply to the discharge of NO_x compounds. Capacities of CCP and DFTP under Phase II Facilities would be below the cut-off limit for Rule 474, and the rule would not apply. Rule 475.1 on the phased reduction of NO_x emission would also not be applicable, due to the provision exempting biomass-derived fuels from the Rule. However, Rule 475 would be applicable to the CCP, and Rule 476 probably to both CCP and DFTP.

Under Rule 475, electrical generating equipment rated at more than 10 net megowatts is limited to 80 ppm of NO_x (gaseous fuel) and 1.7 lb of NO_x per net megowatt hour of electricity generated. Using the present emission factor of 0.30 lb NO_x/mm BTU, the CCP would exceed both the concentration and mass emission limits. It would appear that both limits could be met by use of additional control systems such as water injection to reduce combustion temperature and/or selective catalytic or non-catalytic NO_x reduction.

Rule 476 applies to steam generating equipment and would limit the CCP and DFTP to 125 and 225 ppm NO_x, respectively. For the CCP, the NO_x concentration requirement is to some extent superseded by corresponding requirements in Rule 475a(1). However. the DFTP for the Phase II facilities would be governed by Rule 476, though exempted from Rule 475. Under the reasonable worst case scenario, an additional 16 percent NO_x reduction is anticipated to be required for the DFTP to meet this Rule. Such a reduction appears achievable by operation of the thermal processing reactor in a uniform steady-state manner to maximize NO_x reductions achieved by selective non-catalytic reduction.

In summary, all the Prohibitary Regulations are expected to be met by the CCP and DFTP, with the exception of NO_x limits for CCP and DFTP. It is anticipated that compliance with NO_x regulations can be achieved through use of additional control systems or improved performance of assumed control systems.

TABLE 4

COMPLIANCE STATUS OF PHASE II FACILITIES WITH AQMD PROHIBITIONS REGULATION

REGULATION	DESCRIPTION	DISCHARGE LIMITS OR ALLOWABLE EMISSIONS	PROJECTED EMISSIONS[1] CITY OF L.A.	LACSD	REMARKS
RULE 404	TSP - Conc. Conc. Limits Based on Vol. Discharged	CLA 0.0513 gr/SCF LACSD 0.0474 gr/SCF	0.018 gr/SCF		CCP - Exempted Specifically DFTP - Complies
RULE 405	TSP - WT. Mass limit based on process Wt.	CLA 346 lb/day LACSD 372 lb/day	117 lb/day	155 lb/day	CCP - Not Applicable DFTP - Complies
RULE 407	CO	2000 ppm	CCP DFTP	Negligible 10 ppm	CCP & DFTP - both complies
RULE 409	TSP	0.1 gr/SCF	CCP DFTP	0.002 gr/SCF 0.018 gr/SCF	CCP - DFTP - both complies
RULE 431.1	Sulfur Content of Gaseous fuel	80 ppm H_2S (natural gas) 800 ppm H_2S (refinery gas)			CCP - Digester Gas Exempted DFTP - Not Applicable
RULE 474	Fuel Burning Equipment -NO_x	555 mm BTU/hr heat input rate or above			CCP & DFTP - Not Applicable
RULE 475	Electric Power Generating Equipment	Max. rating 10 net MW and above			DFTP - Not Applicable
	NO_x	● 80 ppm		212 ppm	CCP - additional NO_x reduction reqd. TSP limits met.
		● 1.7 lb/net MWH (CLA 416 lb/day) (LACSD 583 lb/day)	870 lb/day	1360 lb/day	
	TSP	● 11 lb/hr	1.7 lb/hr	2.7 lb/hr	
		● 0.01 gr/SCF		0.002 gr/SCF	
RULE 475.1	Reduction of NO_x				CCP & DFTP exempted due to use of biomass-derived fuel
RULE 476	Steam Generating Equipment	Max. heat Input rate of 50 mm BTU/hr. and above			CCP - additional NO_x Reduction required; superseded by Rule 475a(1) TSP limits met
	NO_x	● 125 ppm (CCP) ● 225 ppm (DFTP)		212 ppm 268 ppm	DFTP - Additional NO_x reduction required. TSP limits met due to compliance with mass limit.
	TSP	● 11 lb/hr	CCP 1.7 lb/hr DFTP 6.1 lb/hr	2.7 lb/hr 8.1 lb/hr	
		or ● 0.01 gr/SCF	CCP DFTP	0.002 gr/SCF 0.018 gr/SCF	

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1. Reasonable planning case emission levels were assumed for all pollutants and processes, except NO_x from DFTP, for which the reasonable worst case is assumed.

OFF-SITE COMPOSTING AT ROUND CANYON

Waste discharge requirements that might be imposed at the Round Canyon site were assessed based on established discharge requirements at the present Coyote Canyon Landfill site and discussions with staff of the Regional Water Quality Control Board - Santa Ana Region. The following discharge specifications may be typical of those which may be applied at Round Canyon:

1. Facilities must be provided to preclude off-site drainage from entering the sludge processing and/or storage areas.

2. On-site runoff which is likely to be contaminated by contact with sludge or sludge based products must be collected and stored. At Coyote Canyon, the drainage system must be capable of storing the storm runoff resulting from a 4.8 inch rainfall in a 24-hour period. The latter is believed to be approximately a 10 year frequency storm and it is required that storage sumps be pumped promptly to provide adequate runoff capacity. Storage requirements at Round Canyon may be greater than that required at Coyote Canyon, particularly if on-site disposal by reuse and evaporation is anticipated.

3. At Coyote Canyon a 6-inch base material with a permeability not greater than 10^{-6} cm/sec is specified. This may not be required at Round Canyon since the site does not overlay refuse or other decomposable material.

4. Sludge processing and storage areas shall be protected from washout or erosion resulting from a 100 year frequency flood.

5. Discharge of stored and treated runoff may be precluded due to a Regional Board policy against direct discharge into any water body tributary to a bay or estuary. On-site storage and reuse or conveyance off-site by truck or pipeline to a wastewater treatment plant are the most likely alternative if direct discharge is precluded.

POTENTIALLY REQUIRED PERMITS

Various permits are expected to be required for construction and operation of proposed Phase II facilities. An overview of potential requirements for each of the LA/OMA operating agencies follows:

City of Los Angeles

- Permits to construct and operate facilities from the South Coast Air Quality Management District

- Waste discharge requirements for disposal of ash/char from the Los Angeles Regional Water Quality Control Board if such requirements currently applicable to the selected disposal site(s) are not adequate.

- Such permits as may ensue from federal regulations related to the recycling of composted sludge.

- Coastal zone development permit from the State Coastal Commission if current permits are not adequate.

Los Angeles County Sanitation Districts

- Permits to construct and operate facilities from the South Coast Air Quality Management District.
- Waste discharge requirements for disposal of ash/char from the Los Angeles Regional Water Quality Control Board if such requirements currently applicable to the selected disposal site(s) are not adequate.
- Such permits as may ensue from federal regulations related to the recycling of composted sludge.
- Coastal zone development permit from the State Coastal Commission if current permits are not adequate.

Orange County Sanitation Districts

- Permits to construct and operate facilities at Round Canyon from the South Coast Air Quality Management District.
- Waste discharge requirements for disposal of composted/air dried sludge from the Santa Ana Regional Water Quality Control Board if such requirements applicable to the selected disposal site(s) are not adequate.
- Waste discharge requirements from the Santa Ana Regional Water Quality Control Board governing potential discharges from site operations.
- Land use permits for the Round Canyon site from the County of Orange and/or the City of Irvine.
- Coastal zone development permit for activities at the Joint Works from the State Coastal Commission if current permits are not adequate.

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APPENDIX A2

DEVELOPMENT OF AIR EMISSION FACTORS

Air emission factors used in the assessment of alternative sludge management projects and the assessment of the proposed sludge management program are described in this appendix. Emission factors for total suspended solids (TSP), nitrous oxides (NO_x), sulfur oxides (SO_x), hydrocarbons (HC), and carbon monoxide have been developed for various unit processes.

The factors presented represent the culmination of efforts which extended over a two year period. Sources of information included literature reviews, actual field and laboratory testing, communications with manufacturers, and discussions with air quality regulatory and planning agencies including the South Coast Air Quality Management District (SCAQMD), the California Air Resources Board (ARB), and EPA Region IX. The factors presented have undergone considerable evolution since initiation of the effort as the result of numerous reviews and better information. In the case of thermal processing, pilot scale, gasification tests were conducted to obtain information for use in development of the emission factors for NO_x and SO_x.

Except for thermal processing, air emission factors given in Table 1 at the end of this discussion, are expressed as pounds per million BTU (lb/mmBTU) of fuel consumed. In developing estimates of mass emission rates of pollutants, each unit process in the sludge treatment train was analyzed to determine the estimated daily fuel consumption. Fuel consumption values were then multiplied by the appropriate emission factor to give the mass emission rate of the individual pollutants. In the case of thermal processing, mass and energy balances were performed around the thermal reactor to determine the estimated flue gas volume and mass. These values were then multiplied by the appropriate emission factors to give the mass emission rate of the individual pollutants from thermal processing.

In all cases, the air emission factors are believed to be attainable with reasonably good engineering design and operating practice. This does not imply that lower emission factors are not attainable. Measures for reduction of the respective emission factors are also outlined in Table 1 for each of the unit processes. It should be noted that the emission factors reported in Table 1 do not reflect the mitigation measures that have been identified.

The emission factors for the thermal processing systems were reviewed by a firm specializing in the field of air pollution control systems.* Control device options for NO_x, TSP, and SO_x emissions from thermal processing were analyzed. This evaluation has disclosed that:

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* KVB INC., (1980), LA/OMA Emissions and Emission Control Study, Report to LA/OMA Project.

- Fabric filter baghouses, electrostatic baghouses, and electrostatic precipitators are viable particulate control options which should meet or exceed the emission factor of 0.01 grains per actual cubic foot (gr/ACF) at 400°F given in Table 1. Electrostatic baghouses are a recent innovation in fabric filter technology which employ electrostatic augmentation and have been commercially available for about a year. This system reportedly can achieve an outlet concentration of 0.0005 gr/ACF at 400°F.

- Wet scrubbing systems using lime can achieve significant reductions in SO_x emissions. An outlet flue gas concentration of 20 ppm (v) reportedly can be achieved from use of such controls on a thermal processing system. The emission factor shown in Table 1 for SO_x from thermal processing corresponds to a concentration of 50 ppm (v) in the flue gas.

- Selective non-catalytic NO_x reduction systems have reliably achieved 50 percent reduction in NO_x emissions. Potential exists for greater reductions in sludge processing applications than those achieved in current commercial applications. Such increased removal efficiences could be achieved through (1) specific design of boiler systems to incorporate NO_x removal at the outset rather than retrofitting of boilers, and (2) steady state operation of the sludge processing system. Prospects for uniform operations are good due to the generally uniform characteristics of the dehydrated sludge and design provisions (e.g. offline storage) that could be incorporated to assure a uniform feed rate.

- Costs for the foregoing levels of control are not extraordinary when viewed in terms of total estimated cost of the proposed sludge management program.

    - Capital investment for emission controls on a system processing about 265 dry tons per day of sludge are about:

        - \$700,000 to \$900,000 for particulate emission controls
        - \$500,000 to \$1,500,000 for NO_x emission controls
        - \$1,300,000 to \$1,400,000 for SO_x controls

    - Corresponding operating costs for the foregoing system are difficult to estimate but are indicated to be about:

        - \$75,000 for particulate emission control via conventional baghouse
        - \$150,000 for non-catalytic NO_x reduction systems
        - \$170,000 to \$250,000 for SO_x controls

    - The foregoing cost ranges result from consideration of several control system types.

It would appear from the foregoing that lower emission factors are achievable through application of innovative control technologies. However, since use of the emission factors given in Table 1 results in a conservative analysis, such factors are used in the analysis. The foregoing opportunities for emission reductions are considered to be potential mitigation measures should adverse impacts be identified and can serve as goals that should be pursued during detailed design of proposed facilities.

TABLE 1
EMISSION FACTORS USED BY LA/OMA FOR ESTIMATING EMISSIONS FROM VARIOUS FACILITIES

(Units - lb/mm BTU of Fuel, Except as Noted)

NO_x AS NO_2, SO_x AS SO_2, Co AS CO, and HC AS CH_4

COMBINED CYCLE PLANT (CCP)

Process Description = Digester gas fueled gas turbine with waste heat boiler.

Emission Controls = None assumed.

Mitigation Measures = Water injection to reduce NO_x formation, H_2S removal from digester gas.

POLLUTANT	FACTOR	REMARKS
TSP	0.014	AP-42 (Ref. 3), Table 3.3.1-2
NO_x	0.30	AP-42, Table 3.3.2-1. Used in place of factor from Table 3.3.1-2 since latter includes internal combustion engines.
SO_x	0.0446 (a) 0.149 (b) 0.446 (c)	Based on average H_2S content in digester gas of 150 ppm (v) for JWPCP (Ref. 34, 35), 500 ppm (v) for Hyperion, and 1500 ppm (v) for OCSD. Assumes 600 BTU/ft^3 of digester gas.
CO	0.120	AP-42, Table 3.3.2-1
HC	0.0307	AP-42, Table 3.3.2-1

STEAM BOILER (DIGESTER GAS)

Process Description = Steam boilers are required for digester heating and as standby for dehydration and thermal pretreatment processes. All boilers are assumed to be digester gas fired.

Emission Controls = No flue gas control equipment is assumed.

Mitigation Measures = H_2S removal from digester gas, wet scrubbing of flue gas for particulate and partial NO_x and SO_x removal.

POLLUTANT	FACTOR	REMARKS
TSP	0.014	AP-42, Table 1.4-1 for industrial process boilers, assumes 1000 BTU/SCF for natural gas.
NO_x	0.120	AP-42, Table 1.4-1, industrial process boilers. Lower end of range used based on source testing and lower adiabatic flame temperature.
SO_x	0.0446 (a) 0.149 (b) 0.446 (c)	Same as for CCP.
CO	0.017	AP-42, Table 1.4-1 industrial process boilers.
HC	0.003	AP-42, Table 1.4-1 industrial process boilers.

STEAM BOILER (LANDFILL GAS)

Process Description = Disposal of wet sludge cake in a refuse landfill could result in enhanced generation of landfill gas. Such gas was assumed to be fired in a steam boiler.

Emission Controls = No flue gas control equipment is assumed.

Mitigation Measures = H_2S removal from landfill gas, wet scrubbing of flue gas for particulate and partial NO_x and SO_x removal.

POLLUTANT	FACTOR	REMARKS
TSP	0.014	Same as digester gas fired boiler.
NO_x	0.120	Same as digester gas fired boiler.
SO_x	0.024 (a) 0.080 (b) 0.240 (c)	About 54 percent of enhanced gas production is projected to result from continued decomposition of sludge (Ref. 44). Since landfill gas derived from refuse contains little sulfur, the emission factors were prorated according to the S content of the respective digester gases.
CO	0.017	Same as digester gas fired boiler.
HC	0.003	Same as digester gas fired boiler.

TABLE 1 (CON'T)

EMISSION FACTORS USED BY LA/OMA FOR ESTIMATING EMISSIONS FROM VARIOUS FACILITIES

(Units - lb/mm BTU of Fuel, Except as Noted)

TRUCKS AND MOBILE EQUIPMENT

Process Description = Diesel engine powered mobile equipment.

Emission Controls = Applicable Federal and State emission controls are assumed.

Mitigation Measures = None.

POLLUTANT	FACTOR	REMARKS
TSP	0.106	Based on review of data for several sources (Ref. 4, 5, 20, 28). Final factor based on Tables 5-4, 5, 6, and 8 from Data Base and Documentation for Estimating Emissions from Motor Vehicles in California, California ARB, 1977, (Ref. 4).
NO_x	0.966	Same as for TSP.
SO_x	0.152	Same as for TSP.
CO	1.28	Same as for TSP.
HC	0.202	Same as for TSP.

RECIPROCATING ENGINES

Process Description = Stationary, internal combustion engines powered with digester gas.

Emission Controls = None assumed beyond applicable Federal and State emission controls.

Mitigation Measures = H_2S removal from digester gas, selective catalytic NO_x reduc- (SCR), catalytic oxidation of hydrocarbons.

POLLUTANT	FACTOR	REMARKS
TSP	0.089	Source test data at JWPCP (Ref. 45)
NO_x	3.40	AP-42, Table 3.3.2-1, assumes 1000 BTU/SCF for natural gas.
SO_x	0.0446(a) 0.149 (b) 0.446 (c)	Same as for CCP.
CO	0.43	AP-42, Table 3.3.2-1
HC	1.40	AP-42, Table 3.3.2-1

POWER GENERATION BY ELECTRICAL UTILITY

Process Description = Conventional steam electric power generation using fuel oil.

Emission Controls = With the exception of SO_x, emission factors are based on 1974 operations of Los Angeles County power plants and reflect emission controls applicable at that period.

Mitigation Measures = None.

POLLUTANT	FACTOR	REMARKS
TSP	0.0386	Based on review of data from several sources (Ref. 3, 5, 17, 46). Final factor based on Table XLVIII, Air Quality Handbook for Environmental Impact Reports, SCAQMD, 1977, (Ref. 5).
NO_x	0.221	Same as for TSP.
SO_x	0.261	Based on 0.25 percent S by weight in fuel oil as per existing requirements.
CO	0.0193	Same as for TSP.
HC	0.0173	Same as for TSP.

TABLE 1 (CON'T)

EMISSION FACTORS USED BY LA/OMA FOR ESTIMATING EMISSION FROM VARIOUS FACILITIES

(Units - lb/mm BTU of Fuel, Except as Noted)

THERMAL PROCESSING

Process Description = Direct fired thermal processing in a reactor of the multiple hearth furnace (MHF) or fluid bed type. The furnace may be operated in a starved air mode with resultant flue gas combusted in an afterburner followed by a waste heat boiler.

Emission Controls = A fabric filter or equivalent for particulate control, flue gas desulfurization by chemical scrubbing for SO_x control, and selective non-catalytic NO_x reduction (SNCR) using NH3 injection are assumed.

Mitigation Measures = Increased particulate removal such as by decreased baghouse loading or use of electrostatically augmented baghouses. Increased SO_x removal in FGD system. Selective catalytic reduction of NO_x in place of non-catalytic reduction, or design for increased removal efficiency in a non-catalytic system.

POLLUTANT	FACTOR	REMARKS
TSP	0.01 grains/ACF @ 400°F	Based on literature review (see cited references), data supplied by baghouse manufacturer (Ref. 21, 25), and consultant review (Ref. 2).
NO_x (sludge only & sludge/manure)	Uncontrolled 1.27 lb/ton of stack gas (wet basis) equal to 400 ppm (v). Assume 50 percent removal efficiency with SNCR.	Based on review of data for several sources (see Ref. 3, 8, 9, 13, 16 in particular), emission testing conducted by LA/OMA using a MHF (Ref. 1), and consultant review (Ref. 2).
NO_x (sludge/refuse)	Uncontrolled 0.635 lb/ton of stack gas (wet basis) equal to 200 ppm (v). Assume 50 percent removal efficiency with SNCR.	Assumes that majority of NO_x is from fuel bound nitrogen (FBN) and that refuse contributes little FBN.
SO_x	0.221 lb/ton of stack gas (wet basis), equal to 50 ppm (v). Assumes FGD system.	Based on literature review (Ref. 3, 10, 16, 32, 36-41 in particular), emission testing conducted by LA/OMA (Ref. 1, 30), and consultant review (Ref. 2).
CO	0.0193 lb/ton of stack gas (wet basis), equal to 10 ppm (v).	Based on data supplied by manufacturer for gasification followed by an afterburner (Ref. 21, 25).
HC	0.011 lb/ton of stack gas (wet basis), equal to 10 ppm (v).	Based on data supplied by manufacturer for gasification followed by an afterburner (Ref. 21, 25).

(a) JWPCP digester gas.
(b) Hyperion digester gas.
(c) OCSD digester gas.

Applications to the Air Quality Management District for permits to operate and construct proposed Phase II facilities have been filed by both the City of Los Angeles (CLA) and the Los Angeles County Sanitation Districts (LACSD). A compilation of air emission factors used by LACSD is presented in Table 2 for informational purposes.

TABLE 2

EMISSION FACTORS USED BY LACSD IN AQMD PERMIT APPLICATIONS

(Units - lb/mm BTU of Fuel, Except as Noted)

NO_x as NO_2, SO_x as SO_2, Co as CO, and HC as CH_4

EMISSION SOURCE	POLLUTANT	FACTOR	REMARKS
Combined Cycle Plant (CCP)	TSP	0.0445	Used one-half of TSP factor for reciprocating engines.
	NO_x	0.23	Based on gas turbine guarantees by Solar Division of International Harvester.
	SO_x	0.0539	Assumes approximately 180 ppm (v) of H_2S in digester gas.
	CO	0.0696	Same as for NO_x.
	HC	0.0197	Same as for NO_x.
Boilers and Flares	TSP	0.0159	AP-42, Table 1.4-1, for domestic and commercial boilers, assumes 945 BTU/SCF LHV for natural gas.
	NO_x	0.127	Same as for TSP.
	SO_x	0.0539	Same as for SO_x under CCP.
	CO	0.0212	Same as for TSP.
	HC	0.0085	Same as for TSP.
Reciprocating Engines	TSP	0.0899	Source test data at JWPCP (Ref. 45)
	NO_x	3.60	AP-42, Table 3.3.2-1, assumes 945 BTU/SCF for natural gas.
	SO_x	0.0539	Same as for SO_x under CCP.
	CO	0.46	Same as for NO_x.
	HC	1.48	Same as for NO_x.
Thermal Processing	TSP	0.0037 gr/ACF @ 400°F	Assumes 100 lb TSP/ton of sludge feed from AP-42, Table 2.5-1, and total removal efficiencies of 0.99995 for fraction greater than 40 microns and 0.995 for fraction less than 40 microns.
	NO_x	Uncontrolled 0.92 lb/ton of stack gas (wet basis). 50 percent removal efficency assumed with SNCR.	Based on 6 lb/ton of feed from AP-42, Table 2.5-1.
	SO_x	0.015 lb/ton stack gas (wet basis), equal to about 3.4 ppm (v). Assumes FGD system.	AP-42, Table 2.5-1, and assumed 90 percent removal efficiency in FGD system.
	CO	0.0168 lb/ton of stack gas	Assumed.
	HC	0.0092 lb/ton of stack gas	AP-42, Table 2.5-1, and assumed 96 percent removal efficiency in thermal reactor.

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APPENDIX B1

ENVIRONMENTAL CONSTRAINT MAPS AND RESULTS OF INITIAL SCREENING PROCESS

This appendix contains maps showing the locations of various environmental constraints for each of the project areas identified by the Regional Environmental Evaluation. Included in this appendix are the following:

Figure	Title
V-1	Geohydrological Constraints - South Los Angeles County
V-2	Geohydrological Constraints - Orange County
V-3	Geohydrological Constraints - S.W. San Bernardino/W. Riverside Co.
V-4	Geohydrological Constraints - Antelope/Victor Valley
V-5	Ecological Constraints - South Los Angeles County
V-6	Ecological Constraints - Orange County
V-7	Ecological Constraints - S.W. San Bernardino/W. Riverside Co.
V-8	Ecological Constraints - Antelope/Victor Valley
V-9	Agricultural Land Capability - South Los Angeles County
V-10	Agricultural Land Capability - Orange County
V-11	Agricultural Land Capability - S.W. San Bernardino/W. Riverside Co.
V-12	Agricultural Land Capability - Antelope/Victor Valley

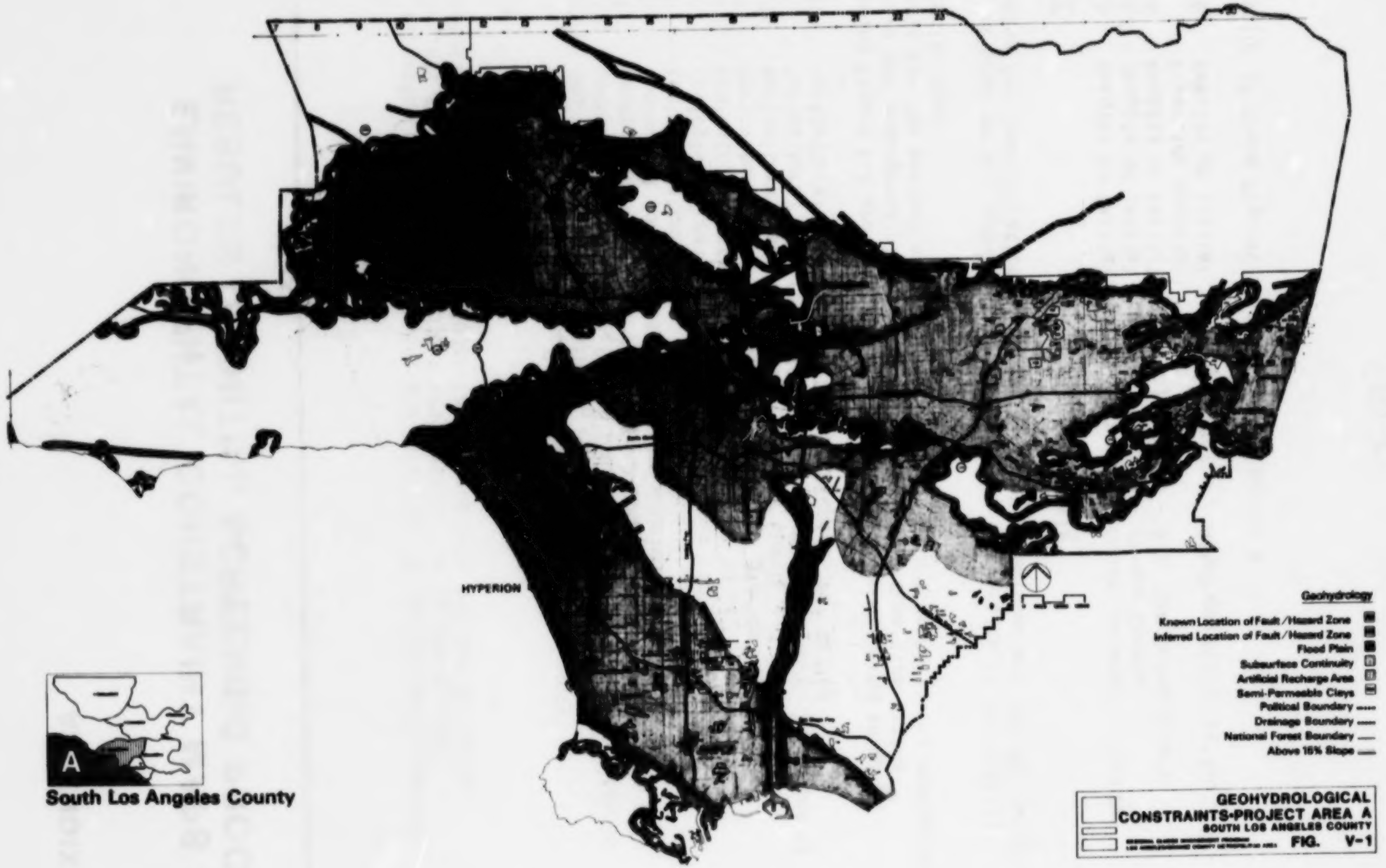
Following Figure V-8 are inventories of (1) rare and endangered animals, (2) rare and endangered plants, and (3) ecologically sensitive native habitats for the project areas. These inventories are keyed to the ecological constraint maps.

Also included in this appendix are maps showing the results of the initial screening for identification of potential sites. Included are the following:

Figure	Title
V-13	Results of Initial Screening Process - South Los Angeles County
V-14	Results of Initial Screening Process - Orange County
V-15	Results of Initial Screening Process - S.W. San Bernardino/W. Riverside Counties
V-16	Results of Initial Screening Process - Antelope/Victor Valley

Discussion of these figures is provided in Chapter V.

B1-2



GEOHYDROLOGICAL CONSTRAINTS-PROJECT AREA A
SOUTH LOS ANGELES COUNTY
FIG. V-1

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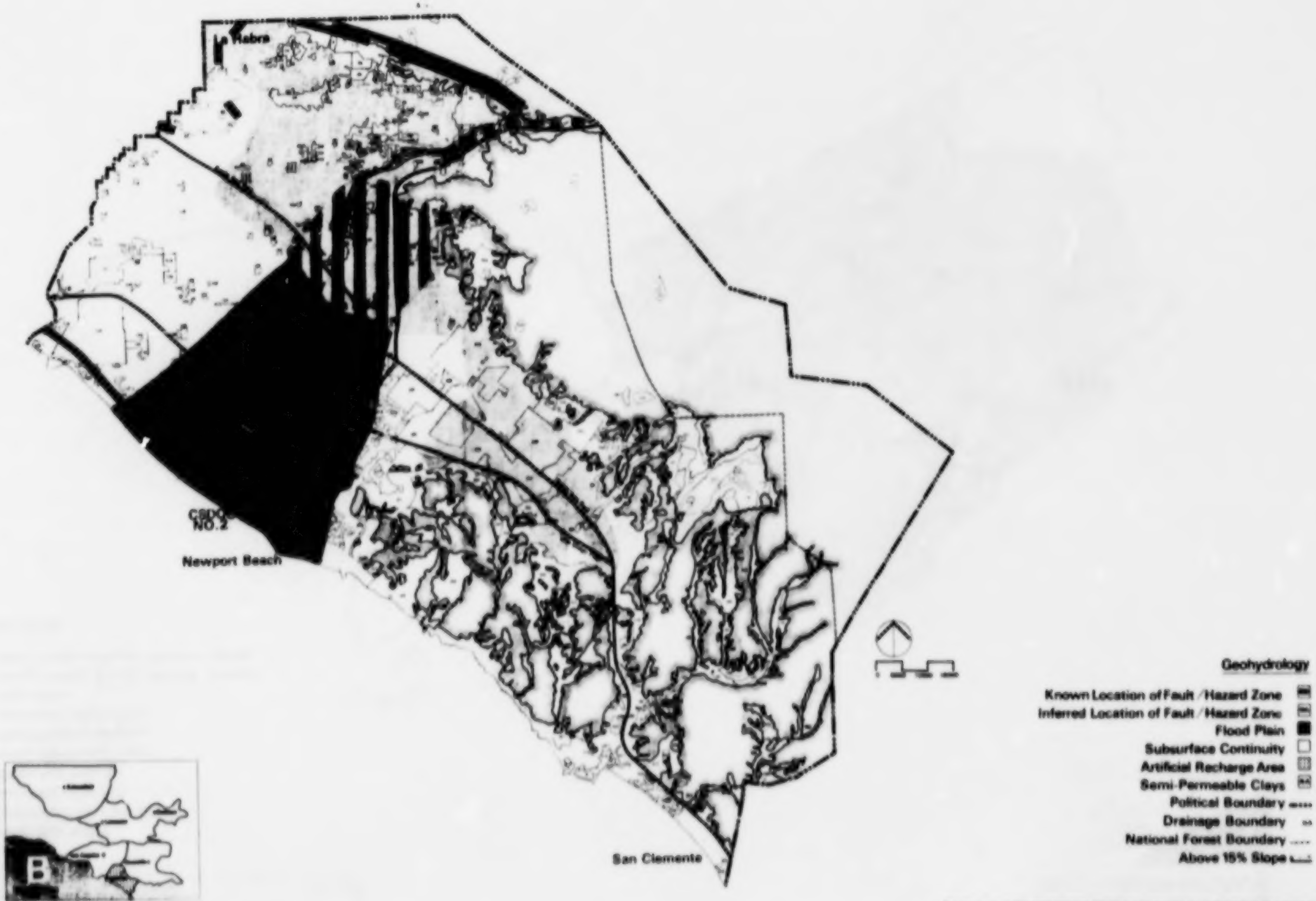
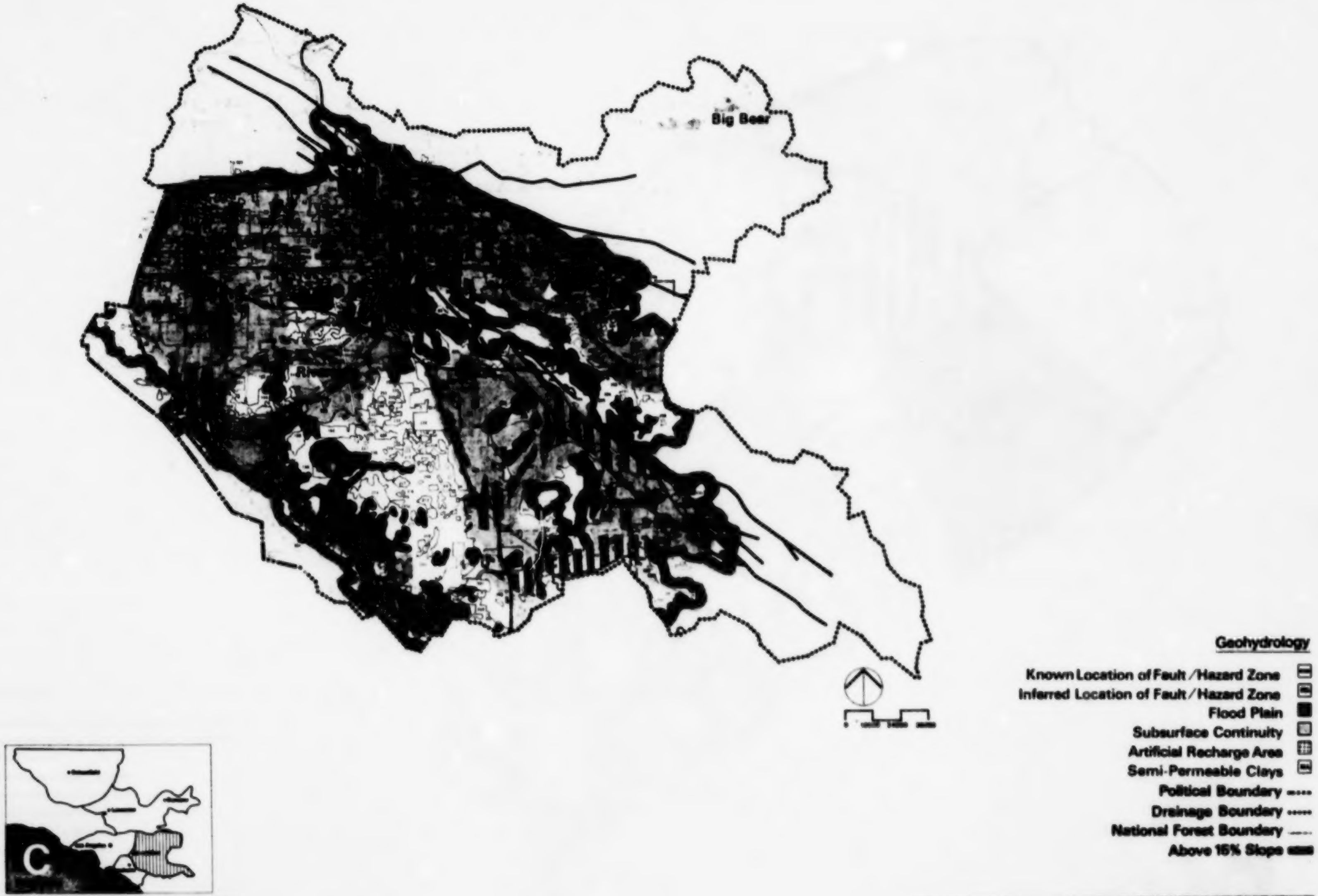


GEOHYDROLOGICAL
CONSTRAINTS-PROJECT AREA B
ORANGE COUNTY
FIG. V-2

B1-3

B1-4



Southwestern San Bernardino/Western Riverside Counties

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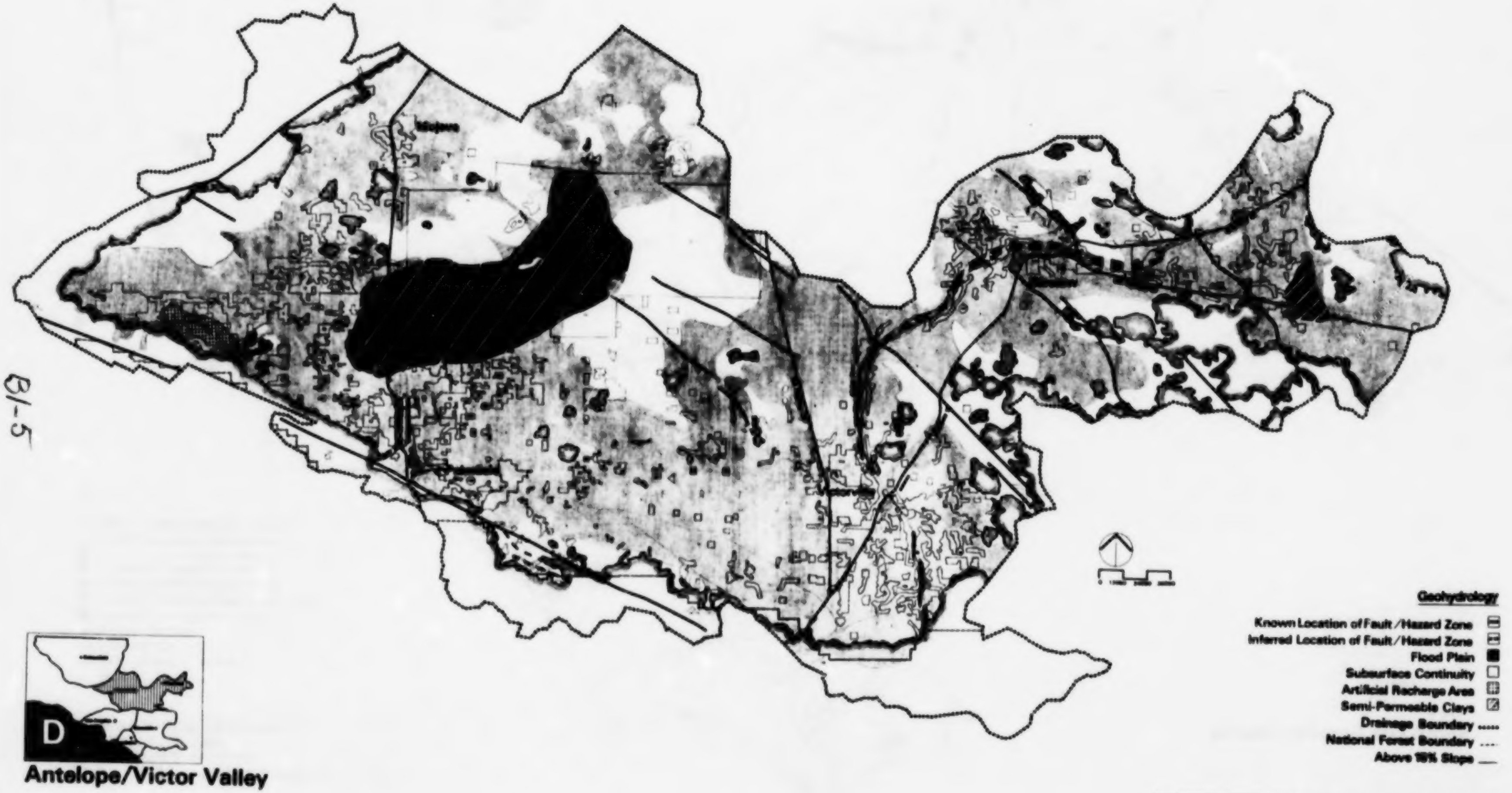
GEOHYDROLOGICAL CONSTRAINTS-PROJECT AREA C

S.W. SAN BERNARDINO/W. RIVERSIDE COUNTIES

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

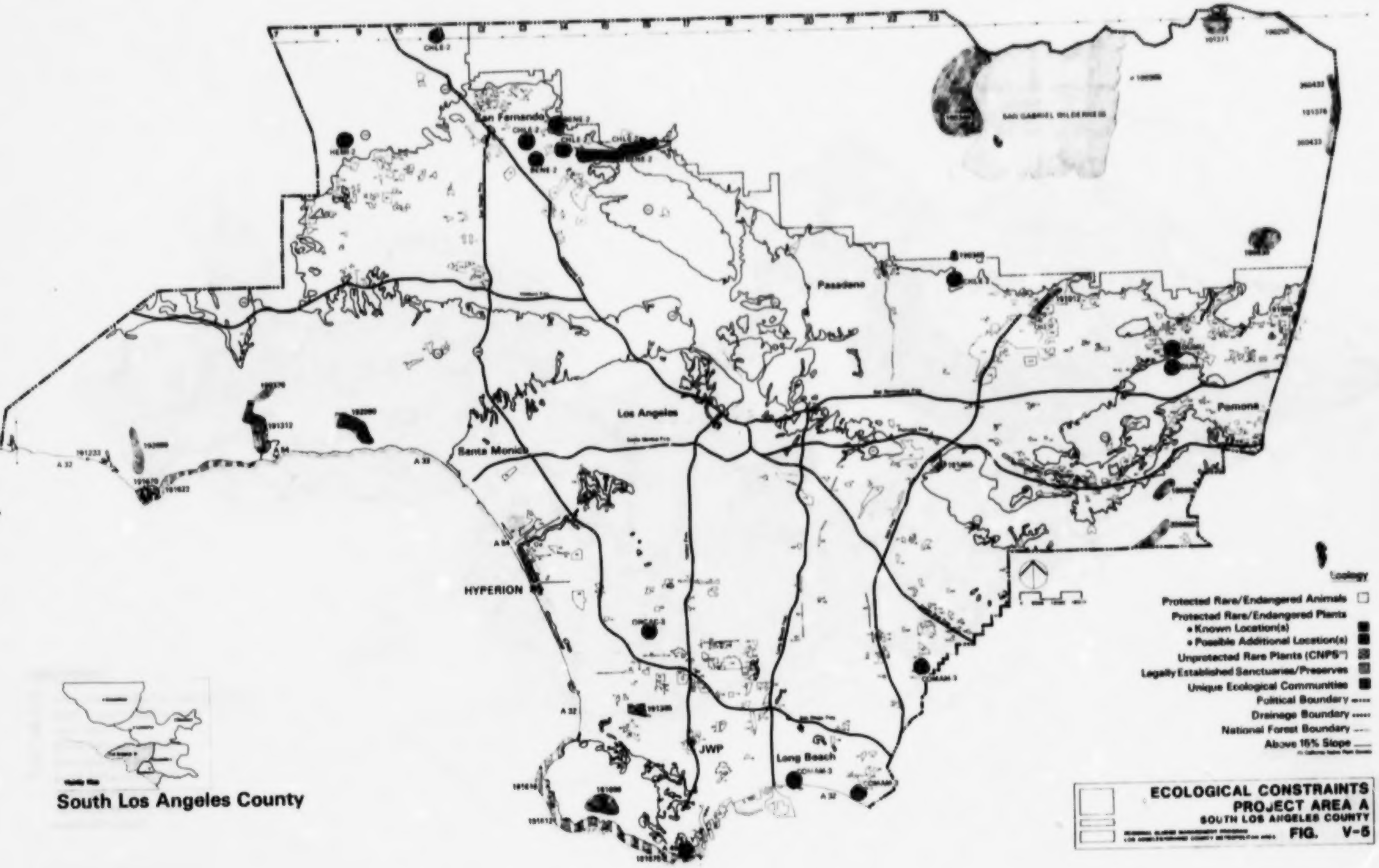
FIG. V-8

B1-5

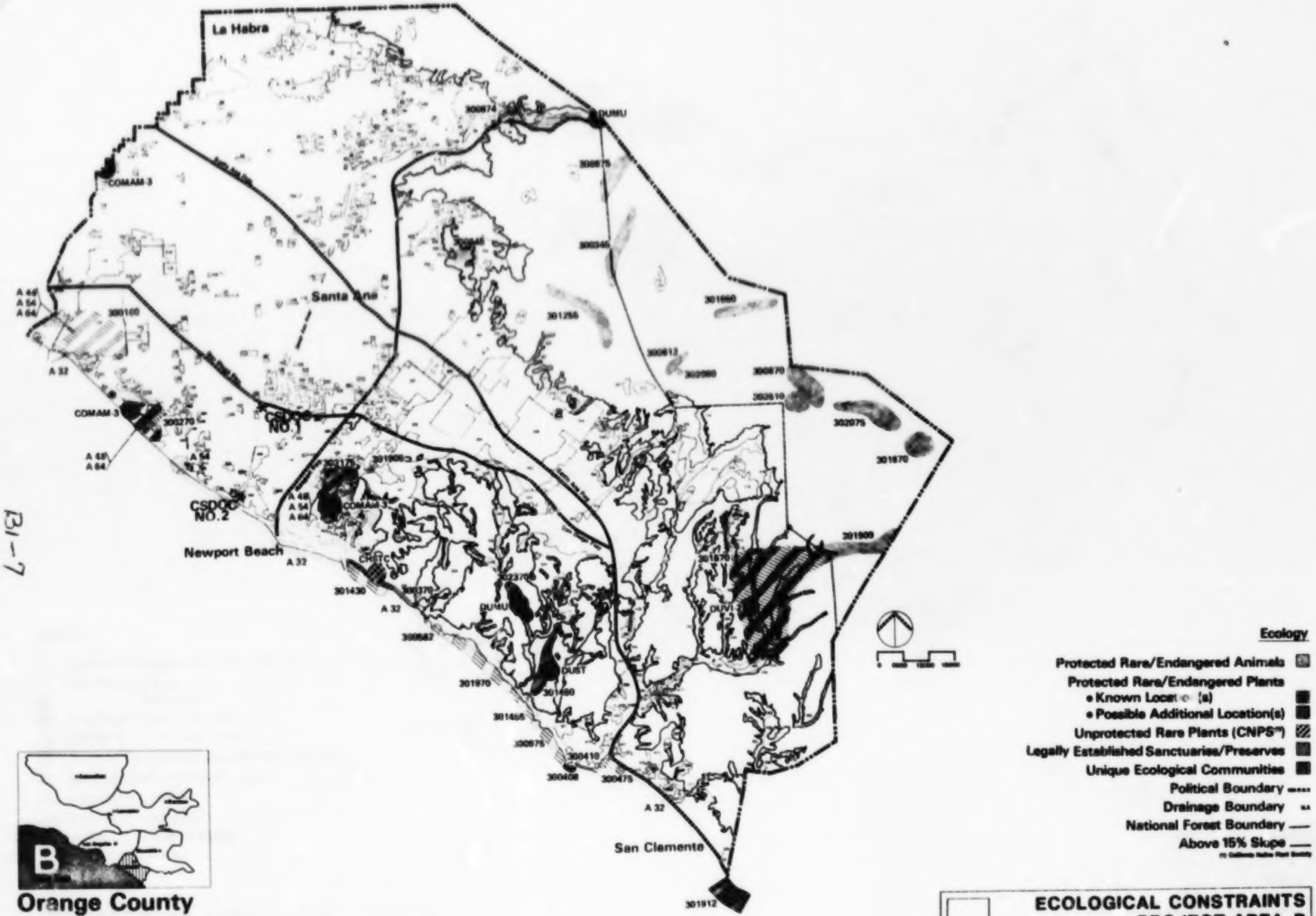


GEOHYDROLOGICAL
CONSTRAINTS•PROJECT AREA D
ANTELOPE/VICTOR VALLEY
REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA
FIG. V-4

B1-6



ECOLOGICAL CONSTRAINTS
PROJECT AREA A
SOUTH LOS ANGELES COUNTY
FIG. V-5



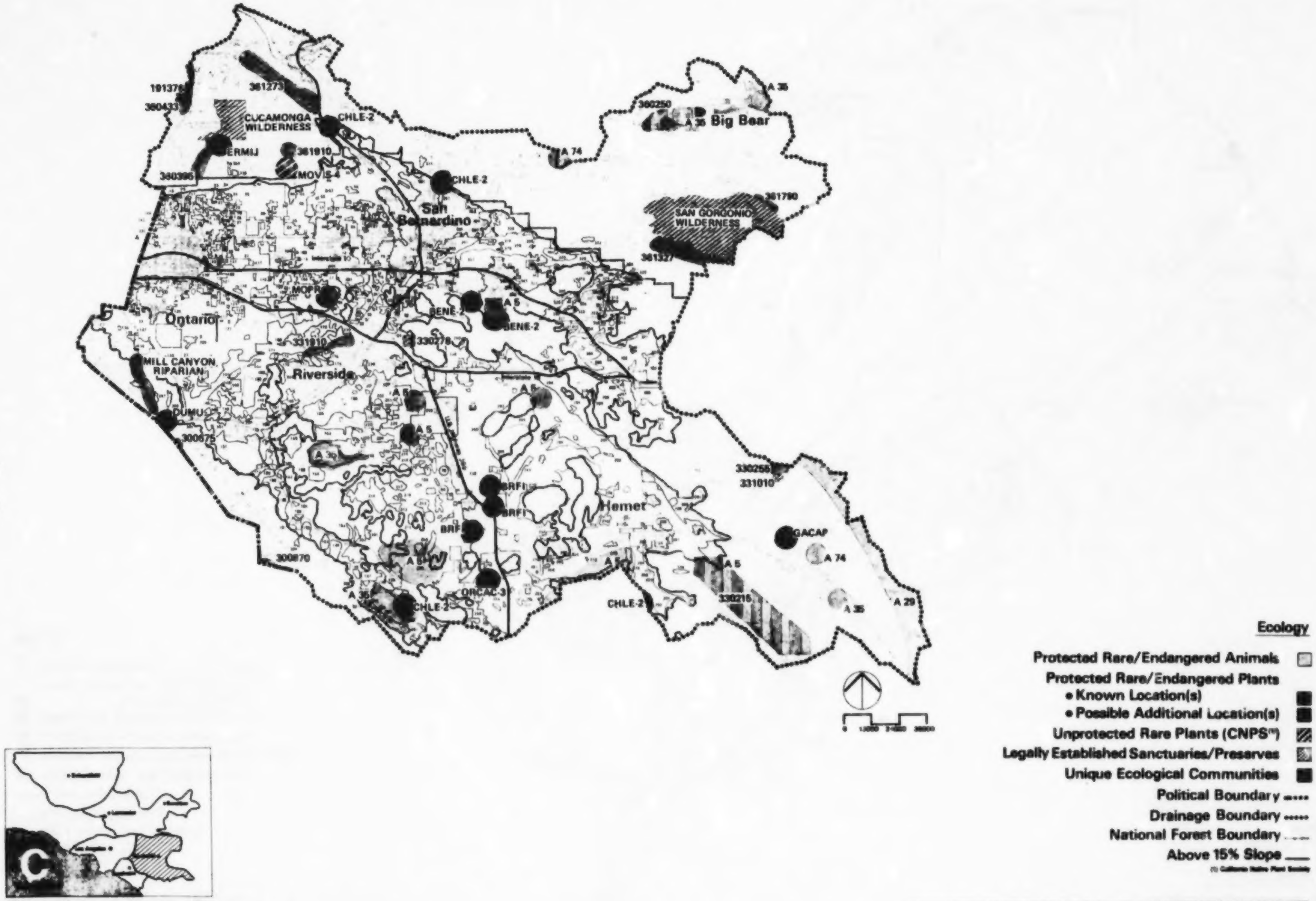
B1-7

ECOLOGICAL CONSTRAINTS
PROJECT AREA B
ORANGE COUNTY

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. V-6

8-12



Southwestern San Bernardino/Western Riverside Counties

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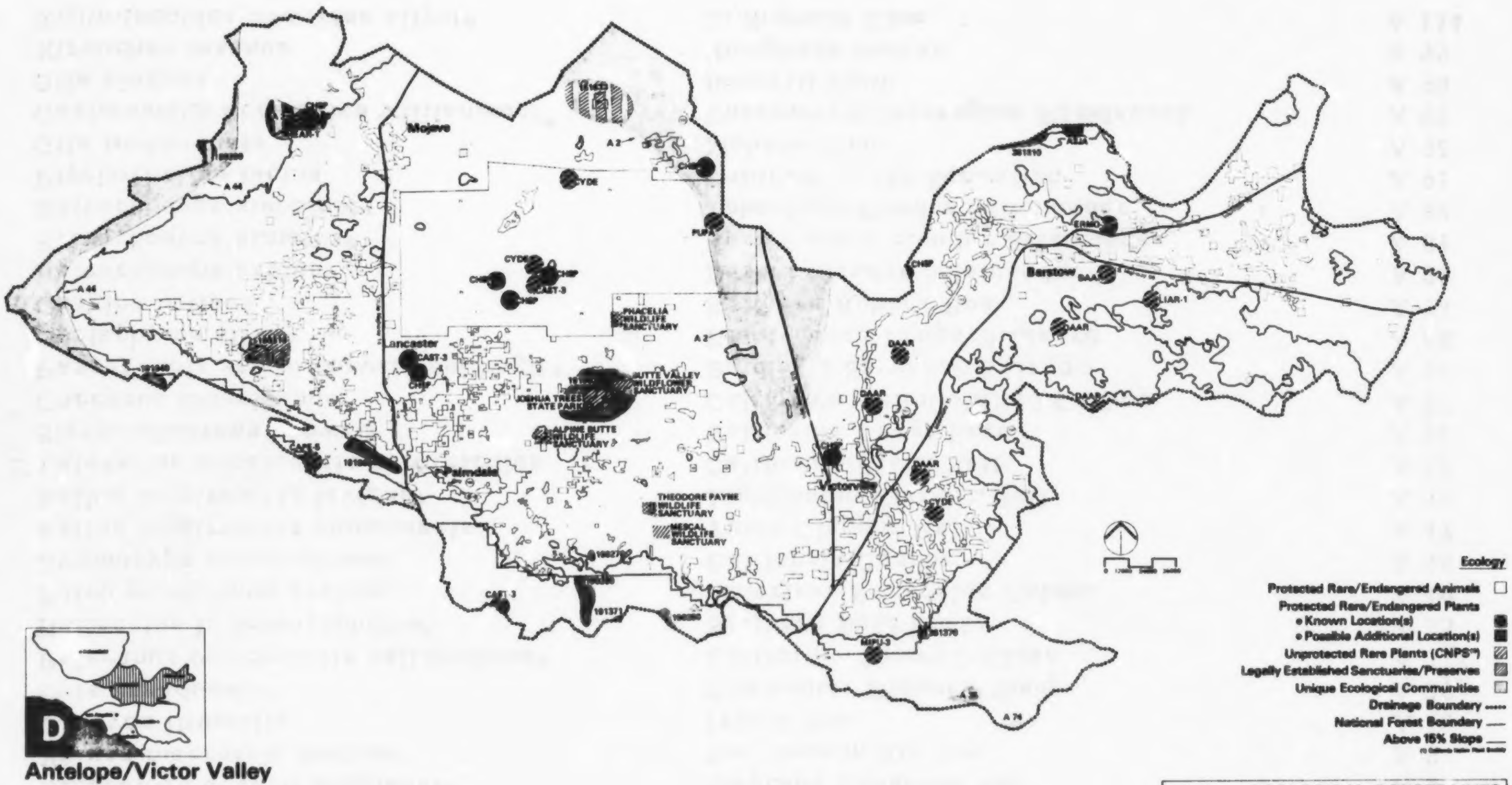
ECOLOGICAL CONSTRAINTS
PROJECT AREA C
S.W. SAN BERNARDINO/W. RIVERSIDE COUNTIES
REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA
FIG. V-7


Antelope/Victor Valley
D
Mojave
Lancaster
Palmdale
Victorville
Barstow
PHACELIA WILDLIFE SANCTUARY
BUTTE VALLEY WILDFLOWER SANCTUARY
JOSHUA TREES STATE PARK
ALPINE BUTTE WILDLIFE SANCTUARY
THEODORE PAYNE WILDLIFE SANCTUARY
MESCAL WILDLIFE SANCTUARY
CYDE
CHIP
CAST-3
CAST-5
PUPA
DAAR
MIPU-3
ERMO
LIAR-1
A 2
A 44
A 74
Ecology
Protected Rare/Endangered Animals ☐
Protected Rare/Endangered Plants
• Known Location(s) ●
• Possible Additional Location(s) ■
Unprotected Rare Plants (CNPS*) ▨
Legally Established Sanctuaries/Preserves ▨
Unique Ecological Communities ☐
Drainage Boundary
National Forest Boundary
Above 15% Slope

ECOLOGICAL CONSTRAINTS
PROJECT AREA D
ANTELOPE/VICTOR VALLEY
FIG. V-8

B1-8.a

INVENTORY OF RARE AND ENDANGERED SPECIES OF ANIMALS FOR THE LA/OMA PROJECT

Scientific Name	Common Name	Code
Citellus mojavensis*	Mojave Ground Squirrel	A 2
Dipodomys deserti stephensi*	Stephens Kangaroo Rat	A 5
Vulpes macrotris mutica*	San Joaquin Kit Fox	A 8
Urocyon littoralis	Island Fox	A 10
Ovis canadensis*	Peninsular Bighorn Sheep	A 29
Pelecanus occidentalis californicus*	California Brown Pelican	A 32
Haliaeetus l. leucocephalus*	Southern Bald Eagle	A 35
Falco peregrinus anatum*	American Peregrine Falcon	A 40
Gymnogyps californianus*	California Condor	A 44
Rallus longirostris yumanensis	Yuma Clapper Rail	A 47
Rallus longirostris levipes*	Lightfooted Clapper Rail	A 48
Laterallus jamaicensis coturniculus	California Black Rail	A 49
Sterna albifrons browni*	California Least Tern	A 54
Coccyzus americanus	California Yellow-billed Cuckoo	A 57
Passerculus sandwicheusis beldingii*	Belding's Savannah Sparrow	A 64
Crotaphytus silus*	Blunt-nosed Leopard Lizard	A 68
Charina bottae*	Southern Rubber Boa	A 74
Batrachoseps aridus	Desert Slender Salamander	A 79
Batrachoseps simatus*	Kern Canyon Slender Salamander	A 81
Batrachoseps stebbinsi*	Tehachapi Slender Salamander	A 82
Ptychocheilus lucius	Colorado River Squawfish	A 91
Gila mohavensis	Mohave Chub	A 92
Gasterosteus acculeatus williamsoni*	Unarmored Threespine Stickleback	A 95
Gila elegans	Bonytail Chub	A 98
Xirauchen texanus	Humpback Sucker	A 99
Shijimiaeoides battoides allyni*	El Segundo Blue	A 114

*Included on LA/OMA Project Map

INVENTORY OF RARE AND ENDANGERED PLANTS FOR THE LA/OMA PROJECT

Scientific Name	Common Name	CNPS Code**
Ambrosia chenopodiifolia	San Diego Bus Sage	AMCH-2
Ambrosia pumila	San Diego Ragweed	AMPU-2
Ammobroma sonorae	Sand Food	AMSO
Androstephium breviflorum	Small-flowered Androstephium	ANBR-1
Angelica callii	Call's Angelica	ANCA-2
Arabis parishii	Parish's Rock-cress	ARPA-4
Arabis shockleyi	Shockley's Rock-cress	ARSH
Astragalus deanei	Dean's Locoweed	ASDE
Astragalus jaegerianus*	Coolgardie Locoweed	ASJA
Astragalus lentiginosus	Borrego Locoweed	ASLEB
Astragalus magdalenae	Peirson's Locoweed	ASMAP
Astragalus subvestitus*	Kern Co. Locoweed	ASSU-1
Atriplex tularensis	Bakersfield Saltbush	ATTU
Atriplex vallicola*	Lost Hills Saltbush	ATVA
Ayenia compacta	Ayenia	AYCO
Berberis higginsae	Higgin's Barberry	BEHI
Berberis nevinii*	Nevin's Barberry	BENE-2
Bouteloua simplex	Mat Grama	BOSI-2

*Included on LA/OMA Project Maps

INVENTORY OF RARE AND ENDANGERED PLANTS FOR THE LA/OMA PROJECT

Scientific Name	Common Name	CNPS Code**
Bouteloua trifida	Mohave Grama	BOTR-1
Brodiaea filifolia*	Thread-leaved Brodiaea	BRFI
Brickellia knappiana	Knapp's Brickellia	BRKN
Brodiaea orcuttii	Orcutt's Brodiaea	BROR-2
Buddleja utahensis	Utah Buddleia	BUUT
Calochortus coeruleus var. westoni*	Shirley Meadows Mariposa	CACOW
Calochortus striatus*	Alkali Mariposa	CAST-3
Calamagrostis densa	Dense Reed Grass	CADE-1
Calochortus dunnii	Cruz Mariposa	CADU-2
Calystegia peirsonii*	Peirson's Morning Glory	CAPE-5
Castela emoryi	Crucifixion Thorn	CAEM
Castilleja cincrea	Ash Grey Indian Paint-brush	CACI-2
Castilleja ewanii	Ewan's Indian Paint-brush	CAEW
Castilleja gleasonii	Mt. Gleason Paint-brush	CAGL-3
Castilleja grisea	San Clemente Id. Paint-brush	CAGR-3
Chorizanthe leptoceras*	Slender-horned Chorizanthe	CHLE-2
Chorizanthe paryi	San Fernando Valley Chorizanthe	CHPAF
Chorizanthe spinosa*	Mojave Spine-flower	CHSP
Chorizanthe staticoides*	Orange Co. Turkish Rugging	CHSTC
Cirsium crassicaule*	Slough Thistle	CICR
Cordylanthus bernardinus	San Bernardino Bird's Beak	COBE
Cordylanthus maritimus*	Salt Marsh Bird's Beak	COMAM3
Cordylanthus mollis	Hispid Bird's Beak	COMOH
Cordylanthus parviflorus	Purple Bird's Beak	COPA-6
Cordylanthus tecopensis	Tecopa Bird's Beak	COTE-1
Coryphantha vivipara	Foxtail Cactus	COVIA
Croton wigginsii	Wiggins Croton	CRWI
Cymopterus deserticola*	Desert Cymopterus	CYDE

*Included on LA/OMA Project Maps

INVENTORY OF RARE AND ENDANGERED PLANTS FOR THE LA/OMA PROJECT

Scientific Name	Common Name	CNPS Code**
Dalea arboreseens*	Smoke Tree	DAAR
Delphinium kinkiense	San Clemente Island Larkspur	DEKI
Delphinium variegatum	Thorne's Royal Larkspur	DEVAT
Dicentra ochroleuca	Yellow Dicentra	DIOC-1
Ditaxis adenophora	Glandular Ditaxis	DIAD
Ditaxis californica	California Ditaxis	DICA-4
Dryopteris filix-mas	Male-fern	DRFI
Dudleya cyrnosa	Santa Monica Mtns. Dudleya	DUCYM1
Dudleya multicaulis*	Many-stemmed Dudleya	DUMU
Dudleya stolonifera	Laguna Beach Dudleya	DUST
Dudleya traskiae*	Santa Barbara Id. Dudleya	DUTR
Dudleya viscida*	Viscid Dudleya	DUVI-2
Enneapogon desvauxii	Nine-awned Pappus Grass	ENDE
Eriogonum breedlovii*	Piute Buckwheat	ERBR-5
Eriogonum deserticola	Desert Eriogonum	ERDE-4
Eriogonum gossypinum*	Cotton Eriogonum	ERGO
Eriogonum ericaefolium	Thorne's Eriogonum	ERERT
Eriogonum heermannii	Clark Mtn. Eriogonum	ERHEF
Eriogonum kennedyi austromontanum	Southern Mountain Eriogonum	ERKEA 2
Eriogonum kennedyi var. pinicola	Kern Eriogonum	ERKEP 1
Eriogonum microthecum johnstonii*	Johnston's Buckwheat Brush	ERMIJ
Eriogonum temblorense*	Temblor Buckwheat	ERTE-5
Eriogonum umbellatum	Alpine Sulfur-flowered Eriogonum	ERUMM 1
Eriophyllum lanatum	Ft. Tejon Woolley Sunflower	ERLAH
Eriophyllum mohavense*	Barstow Eriophyllum	ERMO-3
Eriogoron parishii	Parish's Daisy	ERPA-2
Eriochloa aristata	Awned Eriochloa	ERAR-2
Eschscholzia procera*	Kernville Poppy	ESPR

*Included on LA/OMA Project Maps

INVENTORY OF RARE AND ENDANGERED PLANTS FOR THE LA/OMA PROJECT

Scientific Name	Common Name	CNPS Code**
Eschscholezia ramosa	Island Poppy	ESRA
Fendlerella utahensis	Yerba Desierto	FEUT
Festuca arizonica	Arizona Fescue	FEAR-2
Forsellesia pungens	--	FOPUG
Fritillaria brandegei	Greenhorn Fritillary	FRBR
Fritillaria striata*	Adobe Lily	FRST
Galium californicum ssp. primum*	California Galium	GACAP
Galium catalinense	San Clemente Id. Galium	GACAA
Galium grande	--	GAGR-2
Galium hilendiae	Kingston Galium	GAHIK
Gentiana fremontii	Moss Gentian	GEFR
Haplopappus canus	Island Hazardia	HACA-2
Helianthus niveus	Desert Sunflower	HENIT
Hemizonia arida*	Red Rock Tarweed	HEAR-1
Hemizonia minthornii*	Santa Susana Tarweed	HEMI-2
Hemizonia mohavensis	Mojave Tarweed	HEMO-2
Hibiscus californicus	California Hibiscus	HICA
Horkelia wilderae	--	HOWI
Ivesia argyrocoma	Silver-haired Ivesia	IVAR
Ivesia callida	Tahquitz Ivesia	IVCA-1
Koeberlinia spinosa	Crown-of-thorns	KOSP
Lavatera assurgentiflora	Malva Rosa	LAAS
Layia leucopappa*	Comanche Layia	LALE
Lesquerella bernardina	San Bernardino Lesquerella	LEBE
Linanthus avenicola*	Desert Linanthus	LIAR-1
Linanthus maculatus	Little San Bernardino Mtn. Linanthus	LIMA-2
Lithophragma maximum	San Clemente Id. Woodland Star	LIMA-4
Loeflingia squarrosa	Sage-like Loeflingia	LOSQA
Lotus argophyllus	San Clemente Id. Silver Hosackia	LOARA

*Included on LA/OMA Project Maps

INVENTORY OF RARE AND ENDANGERED PLANTS FOR THE LA/OMA PROJECT

Scientific Names	Common Name	CNPS Code**
Lotus seoparius ssp. traskiae	San Clemente Broom	LOSCT
Lycium hassei	Santa Catalina Desert Thorn	LYHA-2
Machaeranthera lagunensis	Laguna Aster	MALA
Malacothamus clementinus	San Clemente Id. Bush-mallow	MACL-2
Malacothamus parishii	Parish Bush-mallow	MAPA-5
Matelea parvifolia	Spearleaf	MAPA-4
Mentzelia hirsutissima	Hairy Stickleaf	MEHIS
Mimulus exiguus	Mean Monkey-flower	MIEX
Mimulus pictus*	Calico Flower	MIPI-1
Mimulus purpureus*	Purple Monkey-flower	MIPU-3
Monardella linoides	--	MOLIO
Monardella macrantha	Hall's Monardella	MOMAH
Monardella pringlei*	Pringle Monardella	MOPR
Monardella robisonii	Robison Monardella	MORO
Monardella viridis saxicola*	Rock Monardella	MOVIS.4
Muhlenbergia arsenei	Tough Muhlenbergia	MUAR
Navarretia setiloba*	Coville's Navarretia	NASE
Nemacladus twisselmannii	Ephemeral Nemacladus	NETW
Opuntia basilaris treleasei*	Bakersfield Cactus	OPBAT
Orcuttia californica*	California Orcuttia	ORCAC3
Orcuttia greenei*	Green's Orcuttia	ORGR-1
Orobanche parishii	Short-lobed Broomrape	ORPAB
Orobanche valida	Rock Creek Broomrape	ORVA
Orthocarpus lasiorhynchus	San Bernardino Orthocarpus	ORLA-2
Oryzopsis micrantha	--	ORMI-1
Penstemon calcareus	Limestone Penstemon	PECA-1
Penstemon californicus	California Penstemon	PECA-2
Penstemon stephensii	Stephens Penstemon	PEST
Pentachaeta lyonii*	Lyon's Pentachaeta	PELY

*Included on LA/OMA Project Maps

INVENTORY OF RARE AND ENDANGERED PLANTS FOR THE LA/OMA PROJECT

Scientific Names	Common Name	CNPS Code**
Perideridia gairdneri	Gairdner's Yampah	PEGAG
Perideridia parishii	Parish's Yampah	PEPAP
Perideridia pringlei*	Adobe Yampah	PEPR
Phacelia mustelina	Death Valley Round Leaf Phacelia	PHMU-1
Pholisma arenarium	Pholisma	PHAR-3
Pilostyles thurberi	Thruber's pilostyles	PITH
Pinus edulis	Pinyon	PIED
Poa atropurpurea	San Bernardino Bluegrass	POAT
Potentilla multijuga	Ballona Cinquefoil	POMU-3
Potentilla patellifera	Kingston Mtns. Cinquefoil	POPA-6
Pseudobahia peirsonii*	Tulare Pseudobahia	PSPE
Puccinellia parishii*	Parish Alkali Grass	PUPA-1
Quercus tomentella	Island Oak	QUTO
Salvia columbariae	Ziegler's Chia	SACOZ
Satureja chandleri	San Miguel Satureja	SACH-1
Sclerocactus polyancistrus	Mojave Fish-hook Cactus	SCPO
Senecio bernardinus	San Bernardino Butterweed	SEBE
Sidalcea hickmanii	Parish Sidalcea	SIHIP
Sidalcea pedata	Pedate Sidalcea	SIPE
Sphenopholis obtusata	Wedgegrass	SPOB
Stipa arida	--	STAR-1
Streptanthus farnsworthianus*	Evalyn's Jewel Flower	STFA
Taraxacum californicum	California Dandelion	TACA-3
Thelypodium stenopetalum	Slender-petalled Thelypodium	THST
Trichostema austromontanum	Hidden Lake Trichostema	TRAUC
Tridens pilosus	Hairy Triodia	TRPI

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Algodones Dunes Research Natural Area	130155	Imperial
Anza-Borrego State Park	130165	Imperial
Beal's Well	130230	Imperial
Coyote Mtn. Natural Area	130368	Imperial
Creosote Bush Natural Area	130373	Imperial
Crucifixion Thorn Natural Area #1	130376	Imperial
Crucifixion Thorn Natural Area #2	130377	Imperial
Fish Creek Mountains	130652	Imperial
Fossil Canyon Natural Area	130675	Imperial
Harper's Well and San Felipe Creek	130813	Imperial
Imperial National Wildlife Refuge	130960	Imperial
Imperial Wildlife Area	130965	Imperial
Kane Spring	131110	Imperial
Milpitas Wash	131353	Imperial
Obsidian Buttes Area	131512	Imperial
Painted Gorge	131610	Imperial
Picacho and Quartz Peaks Area	131650	Imperial
Picacho State Recreation Area	131653	Imperial
Pumpkin Patch	131690	Imperial
Salton Sea Margin Areas	131910	Imperial, Riverside
Salton Sea National Wildlife Refuge	131914	Imperial
Salton Sea Wetlands	131918	Imperial
YUHA Buttes	132590	Imperial
Back Canyon Piute Cypress Grove*	150210	Kern
Bodfish - Garfield Area*	150213	Kern
Bodfish Piute Cypress Grove Botanical Area and Vicinity*	150215	Kern
Brite Creek Area*	150218	Kern

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Brite Valley - Indian Hills Area*	150220	Kern
Buena Vista Lake Area*	150270	Kern
Buena Vista Mesquite Area*	150275	Kern
Caliente Creek (including Sand Ridge Wildflower Preserve)	150310	Kern
Caliente Creek - Last Chance Canyon Area*	150312	Kern
Cameron Canyon - Mojave Area	150320	Kern
Carneros Rocks and Springs*	150325	Kern
Chico Martinez Canyon*	150345	Kern
Chimney Creek - Canebreak Creek Area*	150349	Kern
Clear Creek (Havilah Area)*	150358	Kern
Comanche Point*	150370	Kern
Comanche Point Wildlife Area*	150372	Kern
Cummings and Double Mountains*	150390	Kern
Delano Voice of America Area*	150430	Kern
Elk Hills Naval Petroleum Reserve #1 & #2*	150563	Kern
El Paso Mountains	150570	Kern
Fort Tejon State Historical Park & Vicinity	--	Kern
Freeman - Indian Wells Canyons Area*	150675	Kern
Goose Lake Area*	150770	Kern
Greenhorn Piute Cypress Grove	150777	Kern
Hobo Ridge Piute Cypress Grove*	150870	Kern
Jawbone Canyon - Cross Mountain Area	151010	Kern
Kern Lakebed Area	151115	Kern
Kern National Wildlife Refuge	--	Kern
Kern River Bluffs*	151125	Kern
Kern River Flood Plain Area*	151128	Kern
Kern River State Park & Vicinity	151129	Kern
Kernville Area*	151135	Kern

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Liebel Piute Cypress Grove*	151250	Kern
Lost Hills Area*	151270	Kern-Kings
Lumreau - Cedar Creek Area*	151290	Kern
Linns Valley*	151295	Kern
Mt. Pinos Summit Plateau*	151375	Kern
Paul Paine Wildflower Preserve*	151612	Kern
Peerless Valley*	151633	Kern
Poso Creek Marsh Area*	151670	Kern
Rand Mountains Desert Tortoise Preserve	151810	Kern
Shark Tooth Hill	151957	Kern
Shirley Meadows	151964	Kern
Ballona Creek Marsh	190210	Los Angeles
Big Pines Cienega*	190250	Los Angeles
Big Rock Creek Canyon*	190260	Los Angeles
Big Tujunga Wash	190265	Los Angeles
Bob's Gap*	190270	Los Angeles
California Poppy Preserve*	190310	Los Angeles
Chantry Flats*	190345	Los Angeles
Charlton & Chilao Flats Area	190348	Los Angeles
Cold Creek*	190370	Los Angeles
Crystal Lake	190395	Los Angeles
Diamond Bar*	190450	Los Angeles
El Segundo Dunes	190560	Los Angeles
Farnsworth Bank Ecological Reserve	190610	Los Angeles
Fern Canyon Research Natural Area	190630	Los Angeles
Firestone Scout Reservation & Vicinity	300650	Los Angeles
Hepatic Gulch	190835	Los Angeles

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Box Springs Reserve*	330278	Riverside
Carbon Canyon	300312	Orange, Riverside
Chuckwalla Mtns.	330348	Riverside
Coxcomb Mtns.	360370	San Bernardino, Riverside
Corn Springs Wash	330370	Riverside
Dead Indian Creek Natural Area	330425	Riverside
Desert Lily Gardens	330430	Riverside
Edmund C. Jaeger Nature Sanctuary and Vicinity	330518	Riverside
Indian Canyons Palm Groves	330955	Riverside
Indio Hills Native Palms Natural Area	330957	Riverside
James San Jacinto Mtn. Reserve*	331010	Riverside
Joshua Tree National Monument	331070	Riverside, San Bernardino
Martinez Canyon - Cottonwood Springs	331320	Riverside
Mecca Hills (including Painted Canyon)	331330	Riverside
Mesa de Burro Orcuttia	331332	Riverside
Mesa de Colorado	331335	Riverside
Mt. San Jacinto State Park	331379	Riverside
Orocopic Mountains	331575	Riverside
Salt Creek Area	331905	Riverside
Salton Sea Margins Area*	131910	Imperial, Riverside
San Jacinto Wilderness	331908	Riverside
San Juan Cyn.	301909	Orange, Riverside
Santa Margarita Ecological Reserve	331912	Riverside
Santa Rosa Plateau Area	331915	Riverside
Thousand Palm Sand Dune Area	332012	Riverside
Whitewater Canyon	332345	Riverside

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Afton Canyon	360135	San Bernardino
Amargosa Canyon	140160	San Bernardino
Amboy Crater	360160	San Bernardino
Big Bear Lake*	360250	San Bernardino
Bigelow Cholla Natural Area	360254	San Bernardino
Big Morango Wildlife Reserve	360258	San Bernardino
Black and Opal Mtn. Area	360265	San Bernardino
Blackhawk Landslide	360270	San Bernardino
Burns Pinon Ridge Preserve	360290	San Bernardino
Cadiz Dunes	360305	San Bernardino
Calico Mtns. Archaeological Site	360310	San Bernardino
Castle Buttes & Mtns.	360316	San Bernardino
Cima Dome	360350	San Bernardino
Cindercone Area	360355	San Bernardino
Cucamonga Canyon Mylonites	360395	San Bernardino
Dale Dry Lake Area	360410	San Bernardino
Devil's Backbone - North	360432	San Bernardino
Devil's Backbone - South*	360433	San Bernardino
Dumont Dunes	360492	San Bernardino
Fourth of July Canyon	360671	San Bernardino
Granite Mountains	360780	San Bernardino
Havasu National Wildlife Refuge	360805	San Bernardino
Ivanpah Mountains & Mescal Range	360995	San Bernardino
Joshua Tree National Monument	331070	San Bernardino
Kelso Dunes (and Devil's Playground)	361130	San Bernardino
Kingston Mtns.	361140	San Bernardino
Lanfair and Round Valleys	361210	San Bernardino

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Lower Lone Pine Canyon	361273	San Bernardino
Mid Hills	361325	San Bernardino
Mill Creek Canyon	361327	San Bernardino
Mitchell Caverns State Reserve	361350	San Bernardino
Mojave River Camp	361370	San Bernardino
Moovalya Marsh	361376	San Bernardino
New York Mountain Highlands	361430	San Bernardino
Nopah Nannofossil Site	361472	San Bernardino
Old Woman Mountains	361560	San Bernardino
Pisgah Crater	361645	San Bernardino
Piute Range	361650	San Bernardino
Providence Mtns.	361675	San Bernardino
Quaking Aspen Stand	361790	San Bernardino
Rainbow Basin Natural Area	361810	San Bernardino
Sacramento Mtns.	361905	San Bernardino
San Gorgonio Wilderness*	361908	San Bernardino
San Sevaine Cow Camp*	361910	San Bernardino
Saratoga Springs	--	San Bernardino
Shadow Mtns.	361948	San Bernardino
Trona Tufa Pinnacles Natural Area	360275	San Bernardino
Turtle Mtns.	362090	San Bernardino
Whipple Mtns.	362345	San Bernardino
Wildhorse Mesa	362350	San Bernardino
Woods & Hackberry Mtns., Vontrigger Hills	362370	San Bernardino
ZZYXX Mineral Springs	362699	San Bernardino

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
Anaheim Bay*	300160	Orange
Black Star Canyon*	300245	Orange
Bolsa Chica Ecological Reserve*	300270	Orange
Carbon Canyon	300312	Orange
Corona Del Mar Bluffs*	300370	Orange
Corona Del Mar Coast	300375	Orange
Dana Point Marine Area*	300408	Orange
Dana Point Marine Life Refuge*	300410	Orange
Doheny Beach Marine Life Refuge*	300475	Orange
El Modeno Hills*	300545	Orange
Emerald Bay*	300562	Orange
Firestone Scout Reservation & Vicinity*	300650	Orange
Fremont Canyon*	300675	Orange
Harding Canyon*	300812	Orange
Heisler Park Ecological Reserve	300830	Orange
Holy Jim Canyon*	300870	Orange
Horseshoe Bend*	300874	Orange
Irvine Coast Marine Life Refuge*	300975	Orange
Laguna Beach Marine Life Refuge	301210	Orange
Laguna Beach (North)	301212	Orange
Limestone Canyon	301255	Orange
Los Alamitos Sage Scrub Area	301265	Orange
Newport Beach Marine Life Refuge*	301430	Orange
Niguel Hill - Aliso Creek*	301450	Orange
Niguel Marine Life Refuge*	301455	Orange
Potrero Los Pinos	301670	Orange
Ronald W. Caspers Memorial Park*	301870	Orange

*Included on LA/OMA Project Maps

INVENTORY OF ECOLOGICALLY SENSITIVE NATIVE CALIFORNIA HABITATS FOR THE LA/OMA PROJECT

Area Name	CNACC Number*	County
San Joaquin Marsh*	301905	Orange
San Juan Canyon*	301909	Orange
San Mateo Point Kelp Bed*	301912	Orange
San Onofre State Beach	371912	Orange
Silverado Canyon	301950	Orange
South Laguna Beach Marine Preserve*	301970	Orange
Tralmco Canyon	302075	Orange
Tucker Wildlife Sanctuary*	302090	Orange
Upper Newport Bay*	302175	Orange
Wood Canyon*	302370	Orange
Yaeger Mesa*	302510	Orange

*Included on LA/OMA Project Maps

Land included in the prime agricultural land category as defined by the Williamson Act includes:

1) All land that qualified for rating of Class I (few limitations restricting their use) or Class II (moderate limitations that reduce the choice of plants and/or require special conservation practices) in the Soil Conservation Service (SCS) land use capability classifications.

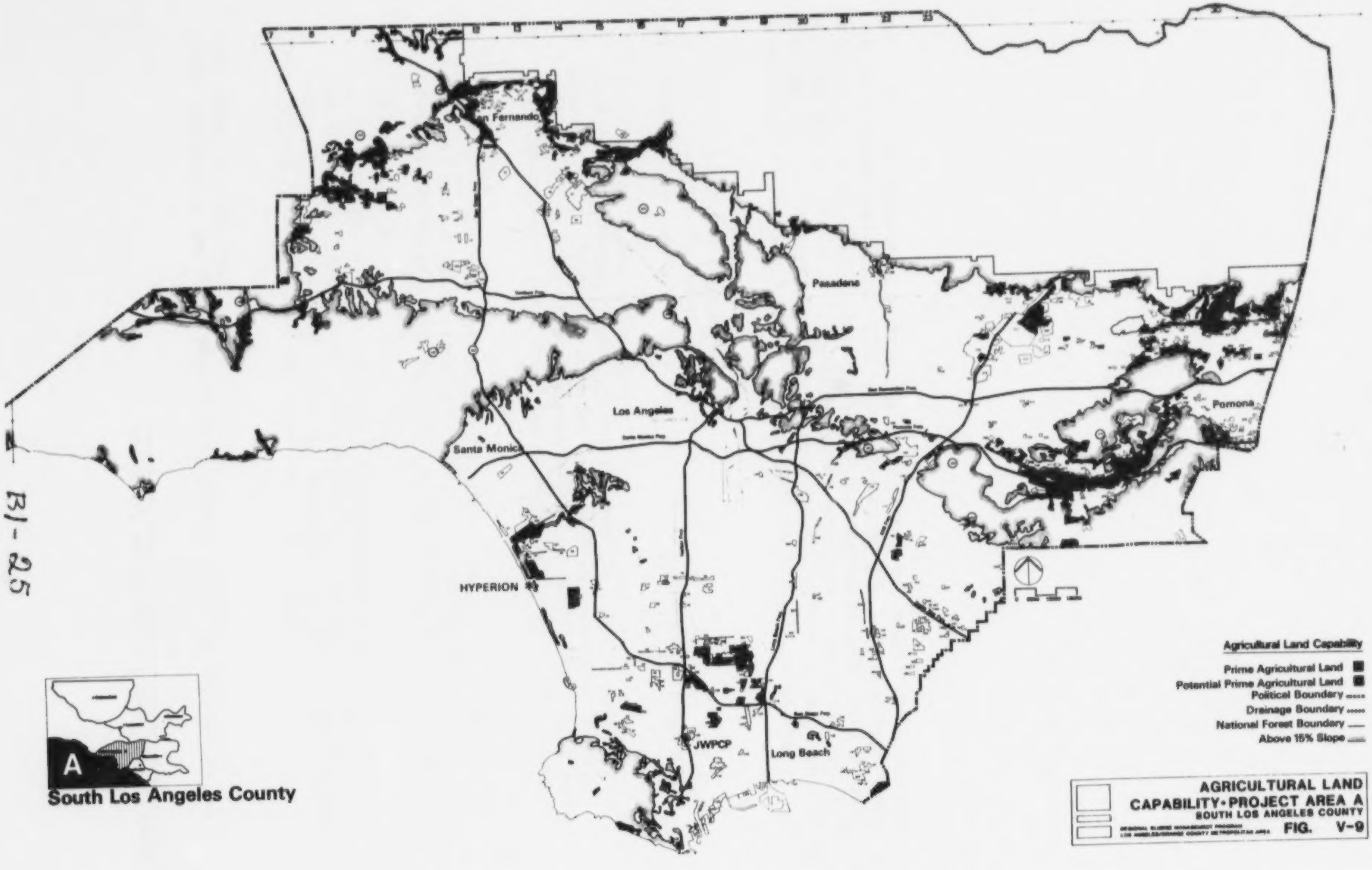
2) Land that supports livestock used for the production of food and fiber and that has an annual carrying capacity equivalent to at least one animal unit per acre, as defined by the United States Department of Agriculture.

3) Land planted with fruit trees (bearing or immature), vines, bushes, or other crops that have a nonbearing period of less than five years and that will normally return not less than $200 per acre annually (during the commercial bearing period from the yield of unprocessed agricultural plant production).

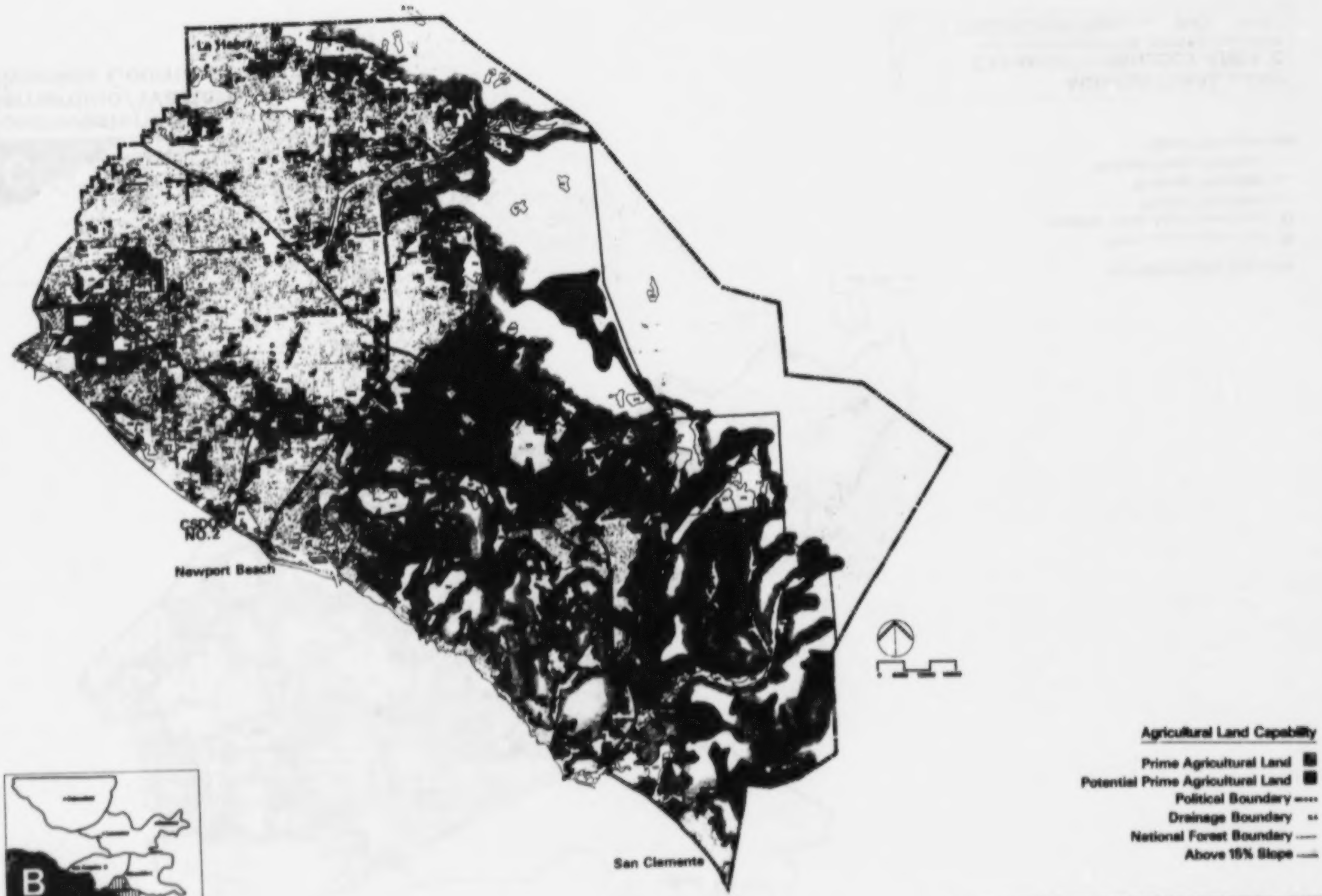
4) Land that has returned from the yield of unprocessed agricultural plant products an annual gross value of not less that $200 per acre for three of the previous five years.

Potentially prime agricultural land has been defined by the Office of Planning and Reserach to include "Lands which have the capability of being made prime through normal agricultural investment and practices". More specifically, potentially prime agricultural lands can be defined as "any lands presently not rating a prime designation that have a potential for producing $200 gross return or supporting pasture with a 12 AUM (animal unit per month) carrying capacity"

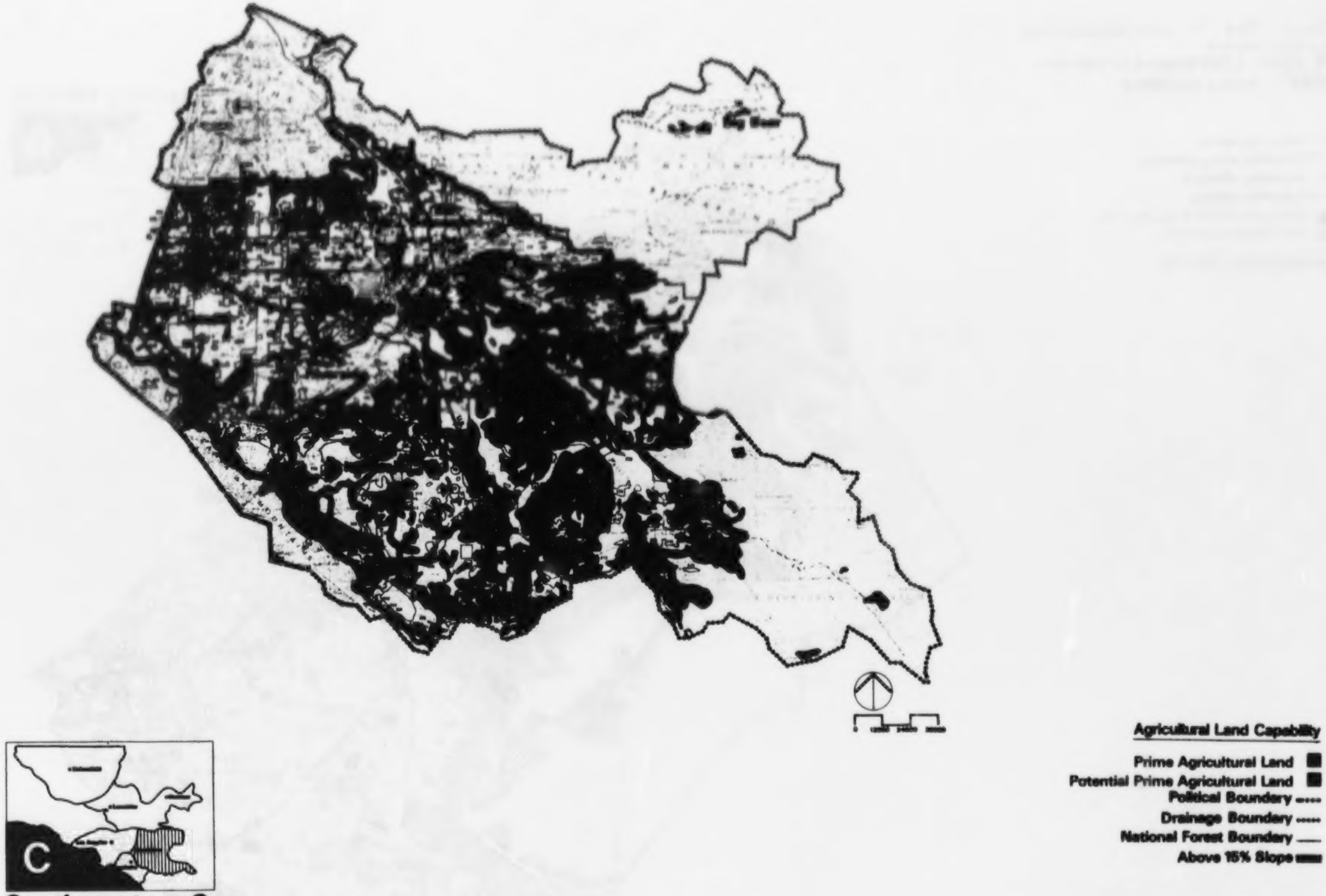
B1-25



AGRICULTURAL LAND CAPABILITY • PROJECT AREA A
SOUTH LOS ANGELES COUNTY
REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA
FIG. V-9



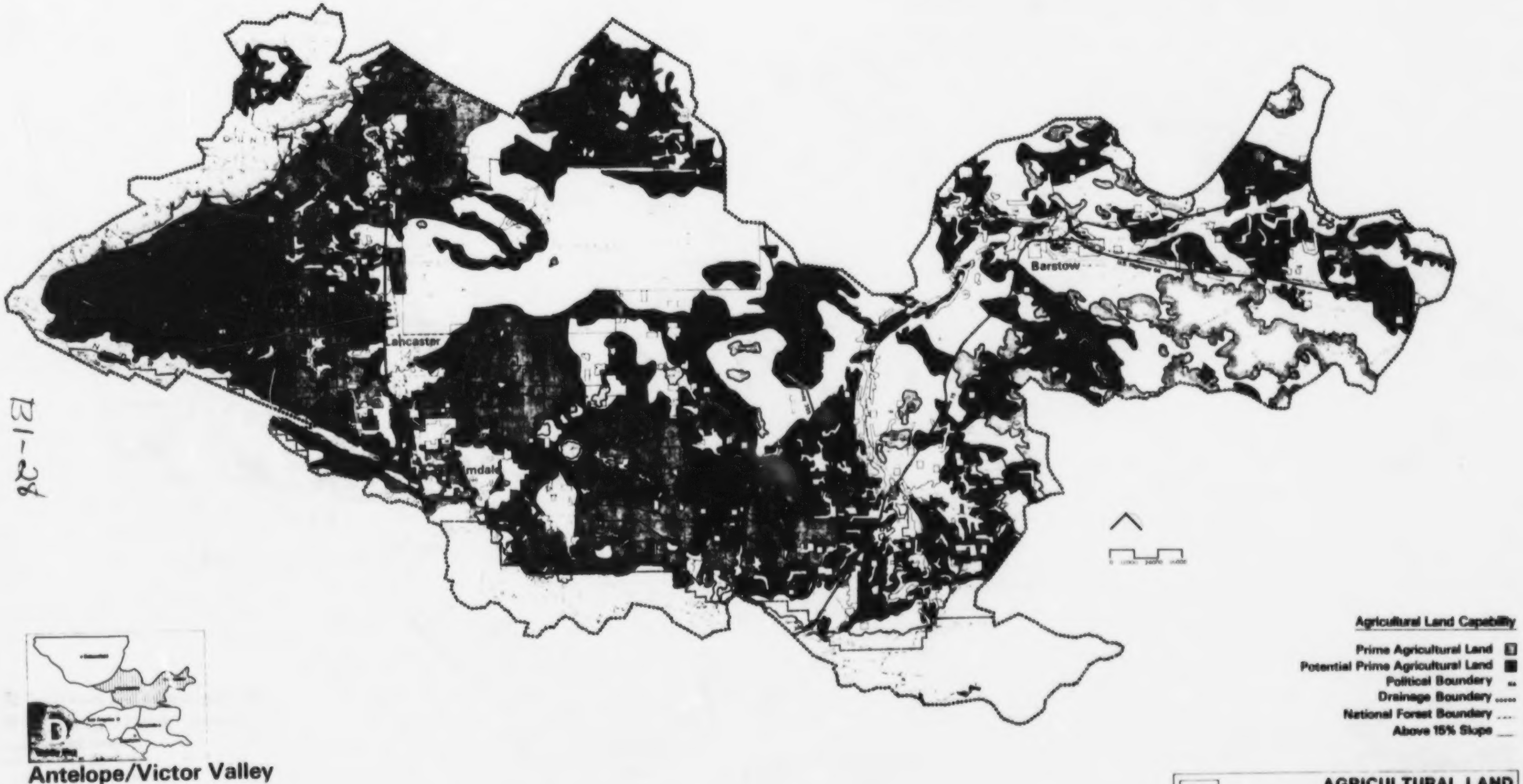
AGRICULTURAL LAND
CAPABILITY • PROJECT AREA B
ORANGE COUNTY
FIG. V-10


C
Agricultural Land Capability
Prime Agricultural Land ■
Potential Prime Agricultural Land ■
Political Boundary
Drainage Boundary
National Forest Boundary
Above 15% Slope
0

Southwestern San
Bernardino/Western
Riverside Counties

AGRICULTURAL LAND
CAPABILITY• PROJECT AREA C
S.W. SAN BERNARDINO/W. RIVERSIDE COUNTIES
REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA
FIG. V-11

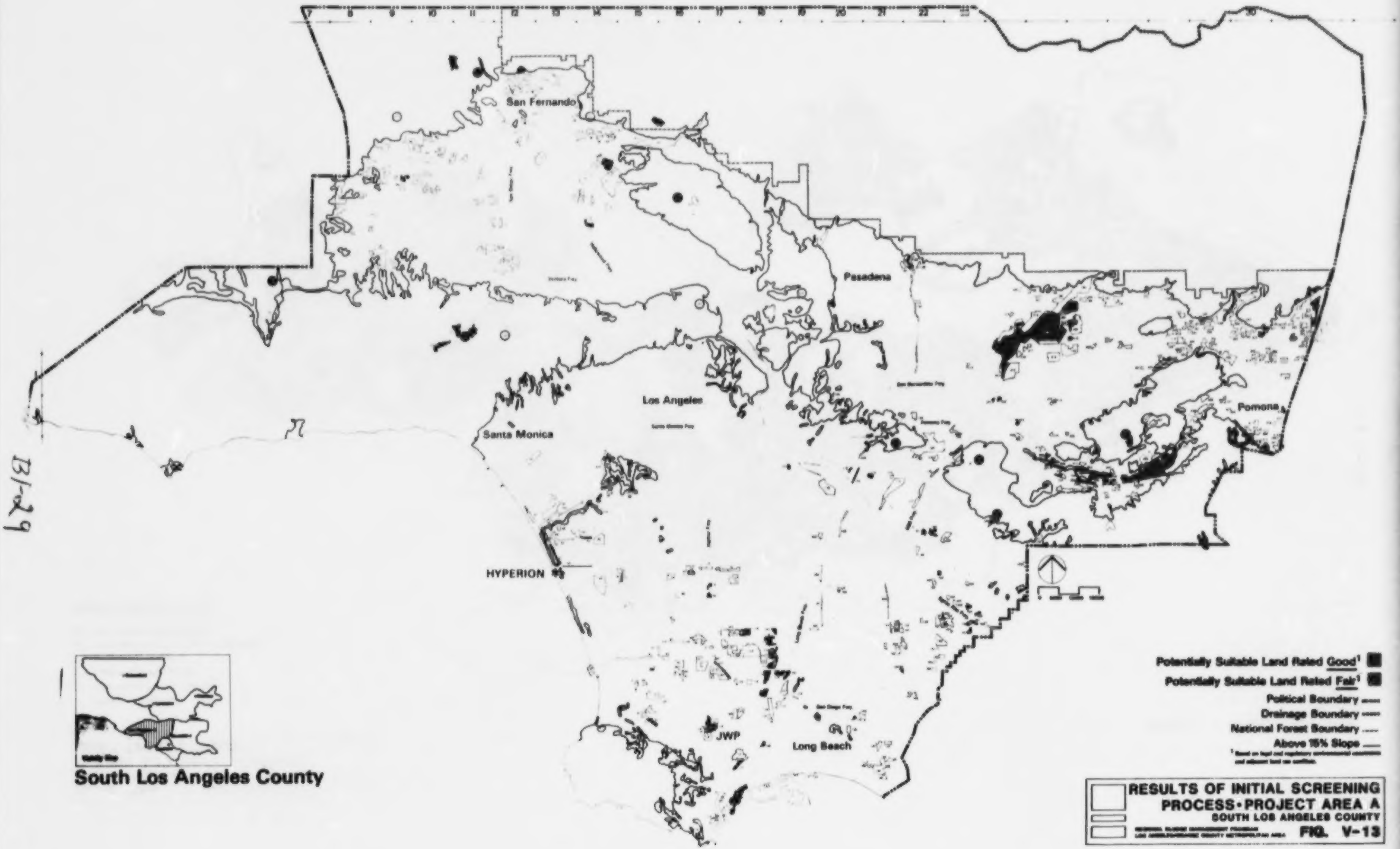
· B1-27



B1-28

AGRICULTURAL LAND
CAPABILITY • PROJECT AREA D
ANTELOPE/VICTOR VALLEY
REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA
FIG. V-12

B1-29



Potentially Suitable Land Rated Good[1] ■

Potentially Suitable Land Rated Fair[1] ▨

Political Boundary

Drainage Boundary

National Forest Boundary

Above 15% Slope

[1] [illegible]

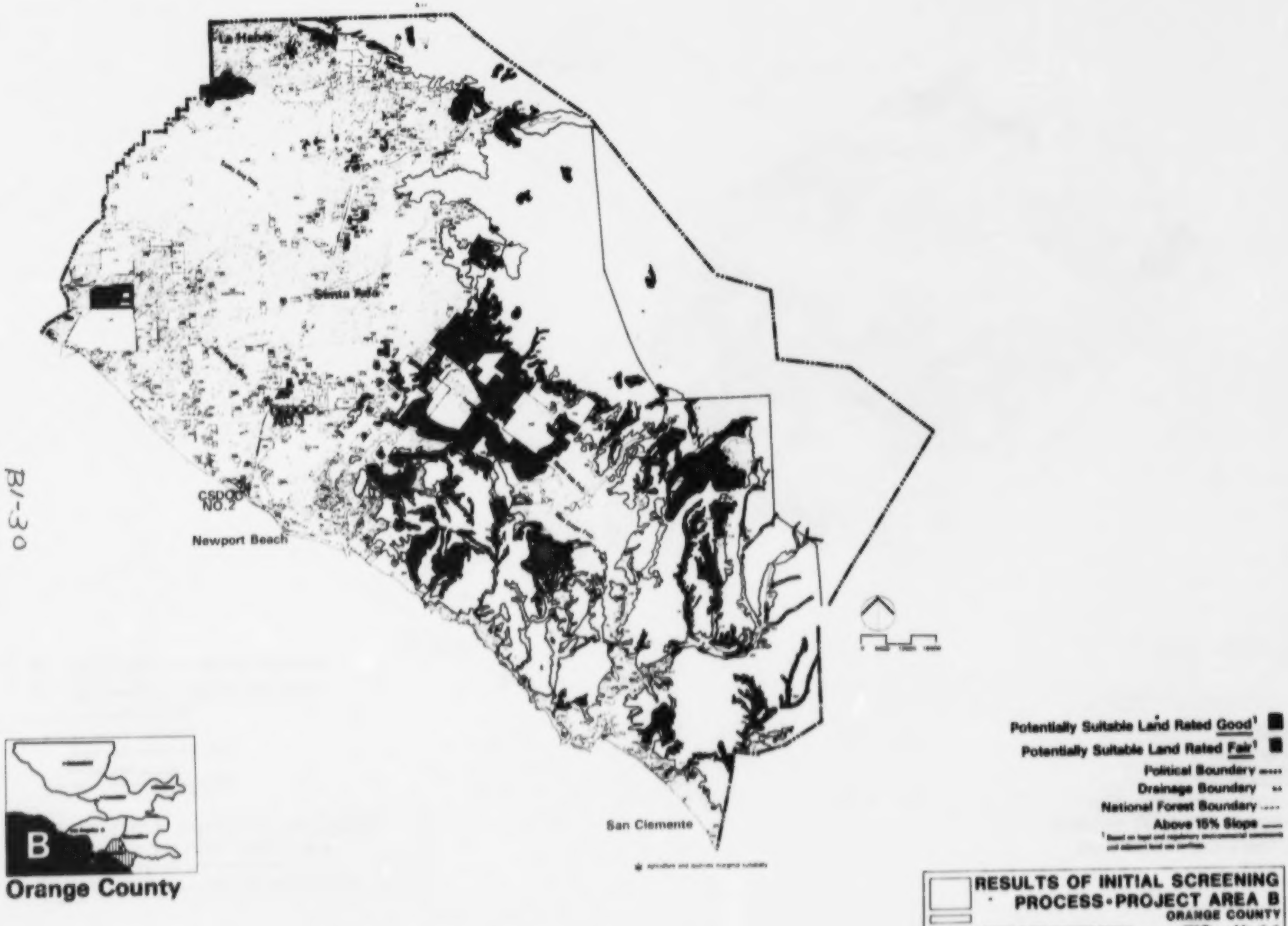
RESULTS OF INITIAL SCREENING PROCESS • PROJECT AREA A

SOUTH LOS ANGELES COUNTY

[illegible]

FIG. V-13

B1-30

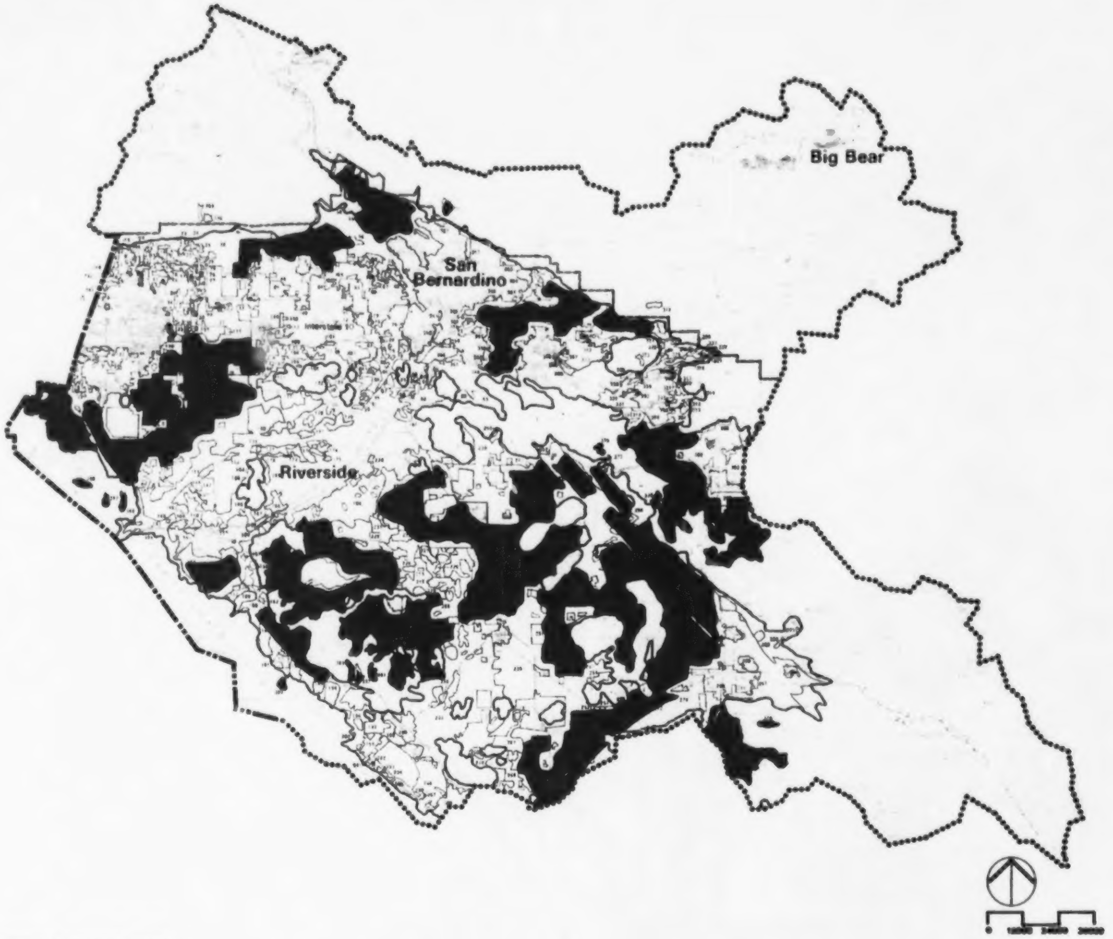

La Habra
Santa Ana
CSDOC NO.2
Newport Beach
San Clemente
B
Potentially Suitable Land Rated Good[1] ■
Potentially Suitable Land Rated Fair[1] ■
Political Boundary
Drainage Boundary
National Forest Boundary
Above 15% Slope
[1] Based on legal and regulatory environmental constraints and adjacent land use conflicts.

Orange County

RESULTS OF INITIAL SCREENING PROCESS • PROJECT AREA B
ORANGE COUNTY

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. V-14



Potentially Suitable Land Rated Good[1] ■ P

Potentially Suitable Land Rated Fair[1] ■ /

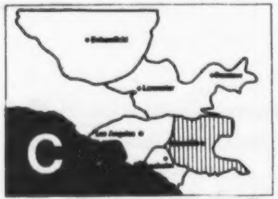
Political Boundary ••••

Drainage Boundary ——

National Forest Boundary ——

Above 15% Slope ——

[1] Based on legal and regulatory environmental constraints and adjacent land use conflicts.



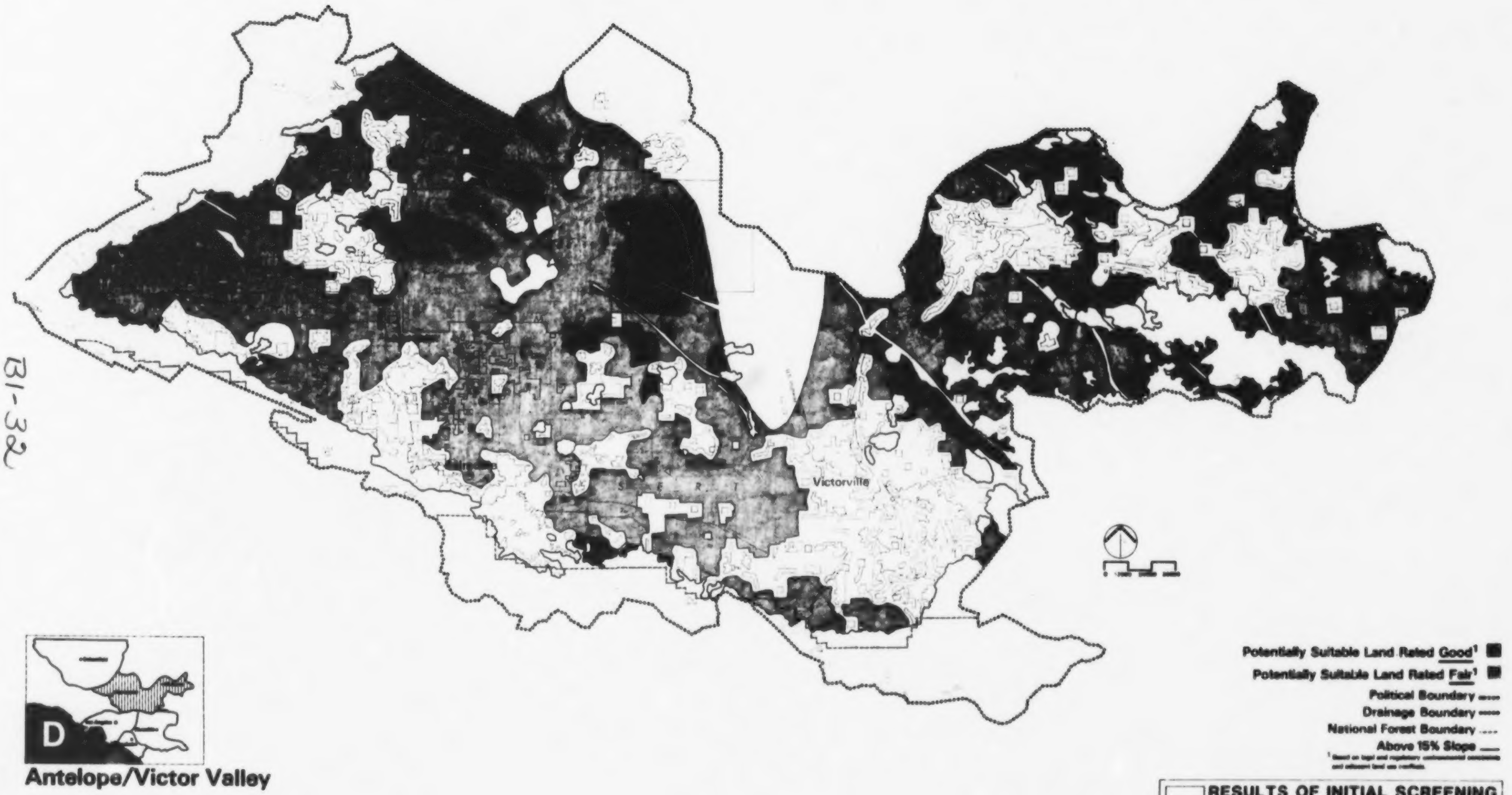
Southwestern San
Bernardino/Western
Riverside Counties

RESULTS OF INITIAL SCREENING PROCESS • PROJECT AREA C

S.W. SAN BERNARDINO/W. RIVERSIDE COUNTIES

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. V-15



Victorville
D
Antelope/Victor Valley
Potentially Suitable Land Rated Good[1] ■
Potentially Suitable Land Rated Fair[1] ▨
Political Boundary
Drainage Boundary
National Forest Boundary
Above 15% Slope
[1] Based on legal and regulatory environmental constraints and adjacent land use conflicts.

DMJM

RESULTS OF INITIAL SCREENING
PROCESS • PROJECT AREA D
ANTELOPE/VICTOR VALLEY
REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA
FIG. V-16

APPENDIX B2

DOCUMENTS PERTAINING TO THE EL SEGUNDO BLUE BUTTERFLY

.) 445-3531

April 24, 1978

Mr. Lynn Greenwalt, Director
U. S. Fish and Wildlife Service
P. O. Box 19183
Washington, D.C. 20036

Dear Lynn:

We have completed our review of the Service's proposed rulemaking for the critical habitat of six endangered California butterflies (FR 42:7972). Based primarily on a contracted study (Arnold 1978) we conclude that: (1) the critical habitat of Lange's metalmark is correct as proposed; (2) the critical habitats of the mission blue, San Bruno elfin, and the El Segundo blue be amended; and (3) the critical habitats of Smith's blue and the lotis blue not be determined at this time.

Specific comments on each species are attached. I hope these comments will be of value to you in preparing the final rulemaking for critical habitat of endangered California butterflies.

Sincerely,

[illegible]

Director

LLE:cm

Attach.

cc: U. S. Fish and Wildlife Service - Portland

bcc: IFB, DD, COP, DRF
San Mateo County Parks and Recreation Department
Edward W. Colson
Dale Sanders
Maurice Leham
Richard Arnold
Gail Kobetich
Howard Leach
Larry Engl

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El Segundo Blue
(*Shijimiacoides battoides allyni*)

We are in agreement with the 2 acres of proposed critical habitat in El Segundo; however, the 250 acres proposed at the Los Angeles Airport appears excessive. Arnold (1978) reported that both the El Segundo blue and its larval food plants are found only in the southern portion of this area. While cogent arguments (scientific, educational, and historical) can be made for allowing this entire area to revert to natural sand dunes, we believe that a critical habitat designation which corresponds to the present distribution of the El Segundo blue and its larval food plants should allow for the "normal needs and survival" of this relatively sedentary species if the area (about 50-60 acres) is properly protected. We believe that the continued existence of this species at the 2 acre El Segundo site supports this position. Critical habitat at the Los Angeles Airport may be delimited by the following components: the area enclosed within a line drawn west along Imperial Highway from its juncture with Pershing Drive to its intersections with Vista del Mar Avenue, thence north on Vista del Mar Avenue to Kilgore Street, thence east on Kilgore Street to Trask Avenue, thence north to World Way; thence east to Pershing Drive; thence south to Imperial Highway.

Smith's Blue
(*Shijimiacoides enoptes smithi*)

This species is more widely distributed in Monterey County than formerly believed and we do not now believe that it qualifies as endangered. We plan to reevaluate the status of Smith's blue and will probably recommend that its status be downgraded to threatened or that it be delisted. We feel that critical habitat for Smith's blue should not be finalized until its status has been reevaluated.

Lotis Blue
(*Lycaeides argyrognomon lotis*)

The primary habitat of lotis blue is a sphagnum bog near Mendocino, California. This species reportedly flies in April-June. Last year, because of the drought, the bog hed no standing water. Arnold (1978) was unable to locate any lotis blue butterflies in five trips to the habitat during the butterflies flight period, April-June. We plan further attempts to locate the species and evaluate its critical habitat this season, but are unable to evaluate the proposed rulemaking for lotis blue critical habitat at this time.

Literature Cited

Arnold, Richard A. 1978. Status of six endangered California butterflies. Calif. Dept. Fish and Game Nongame Wildlife Investigations. E-1-1 Study V, Job 2.20, final report. 95 p.

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EL SEGUNDO BLUE

Distribution

Like the San Bruno elfin, the El Segundo blue (*Shijimiaeoides battoides allyni*) occurs in a region where lepidopterists have collected for many years, yet this taxon was not discovered until recently. Shields (1975) described it as a new subspecies. This taxon now survives on small remnants of the once expansive El Segundo Dunes in Los Angeles County. The dunes originally covered about 36 square miles from what is now the Los Angeles International Airport to San Pedro, California. Museum records reveal that El Segundo blue could be found in El Segundo, Palos Verdes Peninsula, Redondo Beach and North Manhattan Beach.

Today, only two colonies exist: one at Los Angeles International Airport, and the other on two acres owned by Chevron in El Segundo (Fig. 1).

Additionally, there is one small colony of a *S. battoides* population on the Palos Verdes Peninsula. But Lycaenid expert, Dr. R. H. T. Mattoni, believes that this population is not *S. b. allyni*. Along the coastal bluffs from Malaga Cove (Palos Verdes Estates) to Point Fermin (San Pedro), occur widely scattered clumps of the larval buckwheat foodplants--*Eriogonum parvifolium* and *E. fasciculatum*. Most of these clumps are inaccessible due to the steepness of the bluffs. Those that could be checked did not yield any El Segundo blue specimens. All of these areas are located in the coastal fog belt of Los Angeles County.

Coastal strand is the dominant vegetation on the dunes where El Segundo blue occurs. Representative vegetation is listed in Table 1.

Table 1

Representative vegetation at El Segundo blue colonies.

Abronia umbellata variabilis
Artemisia californica
Avena fatua
Baccharis pilularis
Brickellia californica
Brodiaea pulchella
Bromus mollis
Cakile edentula
Chaenactis glabriuscula
Convolvulus cyclostegius
Croton californicus
Datura meteloides
Descurainia pinnata
Dudleya caespitosa
D. pulverulenta
Eriogonum cinereum
E. fasciculatum
E. parvifolium
Erysimum suffrutescens
Eschscholtzia californica
Foeniculum vulgare
Franseria chamissonis
F. c. bipinnatisecta
Gnaphalium leucocephalum
Haplopappus ericoides
Helianthus annuus
Lepidium densiflorum
Lotus micranthus
L. scoparius
Lupinus bicolor
L. longifolius
Malacothrix saxatilis
Mesembryanthemum crystallinum
Oenothera cheiranthifolia
Phacelia ramosissima
Raphanus sativus
Rhus integrifolia
Salsola kali var. *tenuifolia*
Stephanomeria virgata
Tillaea erecta

Essential Habitat

The proposed critical habitat published in the Federal Register (Vol. 42, No. 26) includes both areas where El Segundo blue is known to exist. If the Palos Verdes Peninsula population turns out to be *S. b. allyni*, then the critical habitat will need to include this site.

The problem of most immediate concern is whether the proposed critical habitat at Los Angeles International Airport is too large. Airport officials believed that the El Segundo blue occurred only on the 40 acres south of Kilgore Street, and bounded by Vista Del Mar, Imperial and Pershing Drive on the west, south and east respectively. My investigations revealed that it also inhabits the narrow belt of land bounded by Trask Avenue, World Way, Pershing Drive and Kilgore Street (Fig. 7).

At first glance, this most recently discovered area appears to be largely undisturbed due to its steep slope. A 1965 aerial photo shows that homes were located just east of Trask Avenue and above the steep slope. A few *Eriogonum parvifolium* plants have since recolonized the area formerly occupied by homes. On and at the base of the long steep slope are many specimens of *E. parvifolium* and *E. fasciculatum* both of which are being utilized as foodplants by the El Segundo blue. The butterflies were frequently encountered in this area.

Most of the 200 acres north of Kilgore were severely altered due to the housing development. While some native plants have reestablished themselves on this 200 acres, buckwheats are still restricted only to the narrow strip mentioned earlier and the 40 acres south of Kilgore. Presumably, buckwheat would eventually become reestablished.

I am very reluctant to see the northern 200 acres developed because of the possibility that the dunes might eventually revert to its native state and thus provide a larger area for the El Segundo blue. Nonetheless, airport officials have noted that they are willing to set aside a reserve (south of Kilgore Street) of 40 acres for the butterfly. The reserve should now be expanded to include the recently discovered extension of this colony. If with further study it can be determined that the development and management of the recreational facilities will not adversely affect the microecosystem of the butterfly, then the area of critical habitat could be reduced to the acreage of the reserve only.

Management Recommendations

To ensure the survival of the El Segundo blue, it is recommended that:

1. Colony sites already preserved under private ownership be managed to ensure survival of the butterfly. Several plants, notably ice plant and other noxious and annual weeds, have infiltrated both sites. These need to be controlled as they are encroaching on buckwheat.
2. Habitat enhancement through planting of buckwheat and other native dune plants be done.
3. All vehicular and increased foot traffic be prohibited from these sites.
4. Habitat manipulation be done to ensure the continued survival of the unstable sand habitats and their associated native flora and fauna.

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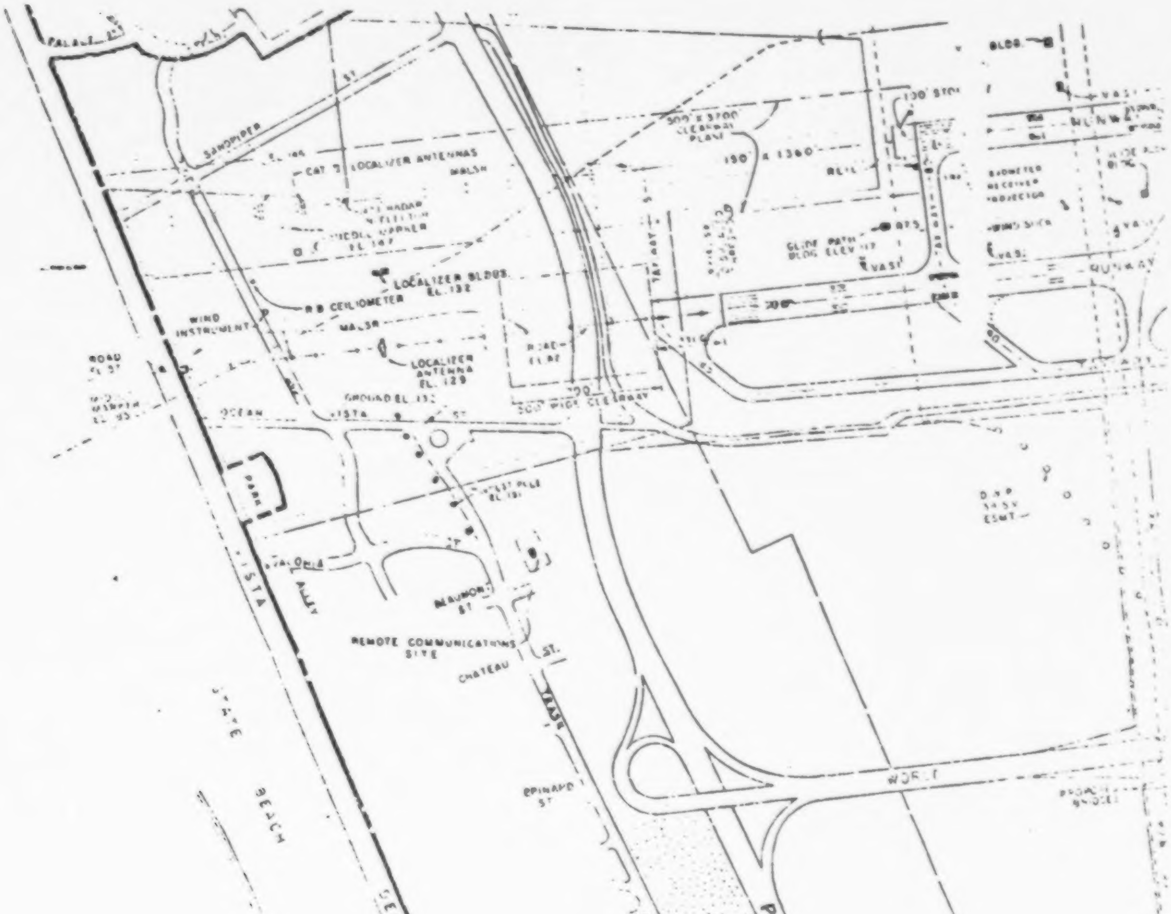
Figure 7. Habitat occupied by El Segundo blue, (stippled area), Los Angeles International Airport



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federal register

TUESDAY, MARCH 6, 1979

PART IV

THE NATIONAL ARCHIVES OF THE UNITED STATES • 1934 •

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

■

REQUIREMENT TO WITHDRAW OR SUPPLEMENT PROPOSALS TO DETERMINE VARIOUS U.S. TAXA OF PLANTS AND WILDLIFE AS ENDANGERED OR THREATENED OR TO DETERMINE CRITICAL HABITAT FOR SUCH SPECIES

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[4310-55-M]

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[50 CFR Part 17]

ENDANGERED AND THREATENED WILDLIFE AND PLANTS

Requirement to withdraw or supplement proposals to determine various U.S. taxa of plants and wildlife as Endangered or Threatened or to determine Critical Habitat for such species.

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Notice.

SUMMARY: The Service provides notice that proposals to list certain species of plants and wildlife as Endangered or Threatened or to determine Critical Habitat for such species pursuant to the Endangered Species Act of 1973 do not meet requirements set forth in the Endangered Species Act Amendments of 1978 (Public Law 95-632, 92 Stat. 3751). Proposals to list species will require supplementation prior to the issuance of final rules. Specifically, the Service will determine whether critical habitat should be proposed for these species. Proposals to determine Critical Habitat are withdrawn and will require re-proposal if appropriate.

FOR FURTHER INFORMATION CONTACT:

John L. Spinks, Jr., Chief, Office of Endangered Species, Fish and Wildlife Service, Washington, D.C. 20240 (703-235-2771).

SUPPLEMENTARY INFORMATION:

BACKGROUND

The Service has made a number of proposals to list species of plants and wildlife as Endangered or Threatened or to determine Critical Habitat for such species pursuant to the Endangered Species Act of 1973. These proposals, made before the Endangered Species Act Amendments of 1978 (hereinafter, Amendments) became effective, do not fulfill certain requirements set forth in that legislation. Specifically, the Amendments require that:

1. A proposal to list a species as Endangered or Threatened be accompanied, to the maximum extent prudent, by a specification of Critical Habitat for the species to be listed, and that notice of any proposal which specifies Critical Habitat be published in a newspaper of general circulation in or adjacent to such habitat.

2. The substance of the FEDERAL REGISTER notice of any proposal to determine a species as Endangered or Threatened or specify its Critical Habitat be offered for publication in appropriate scientific journals.

3. All general local governments located within or adjacent to a proposed Critical Habitat be notified of the proposed regulation at least 60 days before its effective date.

4. A public meeting (and if requested, a public hearing) be held on any proposed regulation which specifies Critical Habitat within the area in which such habitat is located in each State, and, if requested in each such State.

5. A public meeting be held on a proposed regulation which does not specify Critical Habitat if such a meeting is requested by any person within 45 days of the date of publication of the notice of proposal.

6. Any proposed regulation which includes a specification of Critical Habitat be accompanied by a brief description and evaluation of those activities which may adversely modify such habitat or may be impacted by such specification.

7. In determining the Critical Habitat of any Endangered or Threatened species, consideration be made of the economic impact, and any other relevant impacts, of specifying any particular area as Critical Habitat and that any such area may be excluded from a Critical Habitat if the benefits of such exclusion are found to outweigh the benefits of specifying the area as part of the Critical Habitat and if the exclusion would not result in the extinction of the species.

Actions affected by these requirements include:

1. Proposals to list species. These now require supplementation, to the maximum extent prudent, by proposals of Critical Habitat as a result, the Service will propose critical habitat for these species if appropriate. The public will be afforded full opportunity to comment on any such proposal;

2. Proposals to determine Critical Habitat. These are withdrawn, and

3. Proposals to list species and determine Critical Habitat. These are withdrawn only to the extent that they propose Critical Habitat and otherwise require supplementation by proposal of Critical Habitat in the manner discussed above.

All withdrawals made pursuant to this notice are conducted voluntarily by the Service to comply with the provisions of the Endangered Species Act Amendments of 1978 set out above. Because the withdrawals are not required by section 11(5) of the Amendments, the Service need not comply with the requirements of that section prior to reproposal.

Affected proposals are listed below, referenced by publication of notice in the FEDERAL REGISTER:

Proposed title	Date of notice	FR reference
Proposed Endangered status for 216 species appearing on Convention on International Trade [1].	Sept. 26, 1975	40 FR 44329-33
Proposed Endangered or Threatened status for 32 U.S. snails [2]	April 28, 1976	41 FR 17742-6
Proposal to determine 2 birds, 1 lizard, 3 snails, and 1 insect, all indigenous to the California Channel Islands, to be Endangered species [3].	June 1, 1976	41 FR 22073-5
Proposed Endangered status for some 1700 U.S. vascular plant taxa [4]	June 16, 1976	41 FR 24524-72
Proposed determination of Critical Habitat for Grizzly Bear	Nov. 5, 1976	41 FR 48757-9
Proposed Endangered or Threatened status for 41 U.S. species of Fauna [5].	Jan. 12, 1977	42 FR 2507-15
Proposed determination of Critical Habitat for 6 butterflies and 2 plants [6].	Feb. 8, 1977	42 FR 7972-75
Proposed Threatened status and Critical Habitat for the black toad	March 11, 1977	42 FR 13567-69
Proposed determination of Critical Habitat for the Houston Toad [7]	May 26, 1977	42 FR 27009-11
Proposed determination of Critical Habitat for the woundfin	Nov. 2, 1977	42 FR 57329-30
Proposed Endangered status and Critical Habitat for 4 fishes	Nov. 29, 1977	42 FR 60765-68
Proposed Endangered listing and Critical Habitat determination for the Virginia and Ozark big eared bats.	Dec. 2, 1977	42 FR 61290-92
Proposed Endangered status and Critical Habitat for 5 fishes	Dec. 30, 1977	42 FR 65209-12
Proposed Endangered status for the bonytail chub and Threatened status for the razor back sucker.	April 24, 1978	43 FR 17375-77
Proposed determination of Critical Habitat for the Maryland darter	May 12, 1978	43 FR 20518-19
Proposed Endangered status and Critical Habitat for 2 species of Turtles.	May 19, 1978	43 FR 21702-5
Proposed determination of Critical Habitat for the hawksbill sea turtle.	May 24, 1978	43 FR 22224-5
Proposed listing and Critical Habitat determination for 2 Hawaiian cave arthropods.	June 16, 1978	43 FR 26084-7
Proposed determination of Critical Habitat for the Santa Cruz long-toed salamander.	June 22, 1978	43 FR 26759-60
Proposed Endangered or Threatened status or Critical Habitat for 10 butterflies or moths.	July 3, 1978	43 FR 28938-45
Proposed Endangered status and Critical Habitat for the Illinois mud turtle.	July 6, 1978	43 FR 29152-4
Proposed listing and Critical Habitat determination for a fish and a salamander.	July 14, 1978	43 FR 30316-9
Proposed Endangered or Threatened status and Critical Habitat for 10 beetles.	Aug. 10, 1978	43 FR 35636-43
Proposed Endangered and Threatened status and Critical Habitat for 3 Texas fishes.	Aug. 15, 1978	43 FR 36117-20
Proposed Critical Habitat for the whooping crane	Aug. 17, 1978	43 FR 36588-90
Proposed Endangered status and Critical Habitat for the Beaver Dam Slope population of the desert tortoise.	Aug. 23, 1978	43 FR 37662-5
Proposed Endangered status and Critical Habitat for the Virgin River chub.	Aug. 23, 1978	43 FR 37668-70
Proposed Critical Habitat for the Colorado squawfish	Sept. 14, 1978	43 FR 41060-2
Proposed listing and Critical Habitat determination for the Coachella Valley fringe-toed lizard.	Sept. 28, 1978	43 FR 44806-8

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[1] Requires supplementation only insofar as it applies to the species listed below. The remaining taxa affected by this proposal have already been the subjects of a final rulemaking.

Molluscs:

Lampsilis satura—plain pocketbook mussel.

[2] Requires supplementation except insofar as it applies to the species listed below, which have already been the subject of a final rulemaking.

Snails:

Anguispira picta—painted snake coiled forest snail.
Discus macclintocki—Iowa Pleistocene snail.
Mesodon clarki nantahala—noonday snail.
Orthalicus reses—Stock Island tree snail.
Polygyriscus virginianus—Virginia fringed mountain snail.
Succinea chittenangoensis—Chittenango ovate amber snail.
Triodopsis platysayoides—flat-spired three-toothed snail.

[3] Requires supplementation only insofar as it applies to the species listed below. The remaining taxa affected by this proposal have either been previously withdrawn or have already been the subjects of a final rulemaking.

Insects:

Coenonycha clementina—San Clemente coenonycha beetle.

[4] Requires supplementation except insofar as it applies to the following species, which have already been subjects of final rulemakings.

Plants:

Betulaceae, Birch family: *Betula uber*—Virginia round-leaf birch.
Brassicaceae, Mustard family:
  Arabis macdonaldiana—McDonald's rock cress.
  Erysimum capitatum var. angustatum—Contra Costa wallflower.
Crassulaceae, Stonecrop family: *Dudleya traskiae*—Santa Barbara Island liveforever.
Fabaceae, Pea family:
  Astragalus perianus—Rydberg milk-vetch.
  Baptisia arachnifera—hairy rattleweed.
  Lotus scoparius ssp. traskiae—San Clemente broom.
Vicia menziesii—Hawaiian wild broad-bean.
Hydrophyllaceae, Waterleaf family: *Phacelia argillacea*—unnamed phacelia.
Lamiaceae, Mint family: *Pogogyne abramsii*—San Diego pogogyne.
Liliaceae, Lily family: *Trillium persistens*—persistent trillium.
Malvaceae, Mallow family: *Malacothamnus clementinus*—San Clemente Island bushmallow.
Onagraceae, Evening-primrose family:
  Oenothera avita ssp. eurekensis—Eureka evening-primrose.
  Oenothera deltoides ssp. howellii—Antioch Dunes evening primrose.

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Poaceae, Grass family:
  Orcuttia mucronata—Crampton's Orcutt grass.
  Swallenia alexandrae—Eureka dune grass.
  Zizania texana—Texas wild-rice.
Ranunculaceae, Buttercup family:
  Aconitum noveboracense—northern wild monkshood.
  Delphinium kinkiense—San Clemente Island larkspur.
Scrophulariaceae, Snapdragon family:
  Castilleja grisea—San Clemente Island Indian paintbrush.
  Cordylanthus maritimus ssp. *maritimus*—salt marsh bird's beak.
  Pedicularis furbishiae—Furbish lousewort.

[5] Requires supplementation except insofar as it applies to the following species, which have already been the subjects of a final rulemaking.
Fishes:
Etheostoma boschungi—Slackwater dater.
Hybopsis cahni—Slender chub.
Hybopsis monacha—Spotfin chub.
Noturus flavipinnis—Yellowfin madtom.
Speoplatyrhinus poulsoni—Alabama cave fish.

[6] Withdrawn except insofar as it applies to the following species, which have already been the subject of a final rulemaking.
Plants:
Brassicaceae, Mustard family: *Erysimum capitatum* var. *angustatum*—Contra Costa wallflower.
Onagraceae: *Oenothera deltoides* ssp. *howellii*—Antioch Dunes evening-primrose.

[7] Withdrawn insofar as it applies to areas C, D(3), D(4), D(5), and D(6). The other proposed areas have either been previously withdrawn or have been subjects of a final rulemaking.

Comments received from the public concerning the proposals will be considered in the formulation of supplements to meet the requirements of the Amendments. In addition, comments concerning supplemented proposals will be solicited by letter from all persons who have made substantive comments on the original proposals.

The primary author of this notice is Dr. John J. Fay, Office of Endangered Species, U.S. Fish and Wildlife Service, Washington, D.C. 20240 (703/235-1975).

Dated: February 26, 1979.

LYNN A. GREENWALT,
Director, Fish and Wildlife Service.

[FR Doc. 79-6675 Filed 3-5-79; 8:45 am]

submission of the data required from all nominees.

(f) Immediately following the close of nominations, the Chair of the Nominating Committee shall post in the Meeting hall and at the delegate registration desk, the names of all nominees, together with a brief statement of their background and affiliations according to Commission instructions.

(g) The Nominating Committee shall prepare ballots listing the names of all Nominating Committee candidates, with appropriate spaces for write-in votes or for names of floor nominees.

§ 1904.17 Election.

(a) The Coordinating Committee shall appoint an Elections Committee which shall have charge of elections, with authority to decide any challenge to the validity of a ballot or compliance with the rules. Every ballot shall be counted where the intent of the voter is clear.

(b) The Coordinating Committee shall fix the hours for nomination and for the elections, including the hour for closing the polls. This information shall be included in the printed program.

(c) Election shall be by ballot. No ballots shall be distributed prior to the closing of nominations. Ballots will be issued only to those wearing voter registration badges, and each voter's badge will be marked upon the casting of her ballot.

(d) A plurality vote shall elect. The allowable number of persons receiving the highest number of votes shall be the elected representatives. In the event of a tie vote for the finally allotted post, there shall be a further ballot to resolve this selection, the loser to be designated as first alternate. A total of five alternates shall be allowed, ranked according to votes received, who shall be named to serve as representative in the event of the absence or incapacity of an elected representative.

(e) The Elections Committee shall supervise and direct the work of the tellers in the counting of ballots. Several sets of tellers shall be named, each set to consist of four persons, two to look over each ballot together while one reads it aloud, and two to record the vote on the tally sheet. The Elections Committee Chair shall combine the results from the tellers into a final election report which shall be announced to the Meeting. Tellers shall maintain strict secrecy as to the outcome of the voting until such time as the final report is given to the Meeting.

(f) The Elections Committee Chair shall be responsible for the safety and custody of the ballots along with tally sheets, and turn them over to the Presiding Officer to be held for at least 24 hours.

(g) Each State Representative and alternate elected to attend the National Conference shall be issued a certificate attesting thereto which shall be signed by the Chair of the Coordinating Committee and the Recording Secretary of the State Meeting.

Subpart D—Conduct of the State Meeting

§ 1904.18 Discussion groups.

(a) Workshops or other scheduled discussion groups shall have a Chair and a Recorder and shall be conducted under the procedures set out in §§ 1904.10–1904.12 above.

(b) Recommendations for action by the scheduled work groups or by the Coordinating Committee. Proposals for action from any other source may be entertained only after a majority vote to consider.

§ 1904.19 Doorkeepers and timekeepers.

Doorkeepers shall require the showing of registration badges for admission to the Meeting. The timekeepers shall indicate to each speaker the expiration of the time allowed.

§ 1904.20 Credentials Committee.

The Credentials Committee shall be responsible for requiring proper information for registration, and shall have authority to decide any registration question. It shall report the registration to the State Meeting as scheduled in the printed program or as requested by the Presiding Officer.

§ 1904.21 Minutes.

(a) Accurate and detailed minutes shall be kept on the plenary sessions, which shall be submitted to the Commission.

(b) The Recording Secretary, the Chair of the Coordinating Committee, and the Presiding Officer shall be authorized to give final approval to the minutes. The Chair of the Coordinating Committee shall be responsible for furnishing a copy of the minutes to the Presiding Officer of the Commission within 30 days after the close of the State Meeting.

§ 1904.22 Parliamentary authority.

In matters not covered by these rules, Roberts Rules of Order, Newly Revised, shall be the parliamentary authority.

Dated: February 2, 1977.

ELIZABETH ATHANASAKOS,
Presiding Officer, National Commission on the Observance of International Women's Year.

[FR Doc.77-3636 Filed 2-7-77;8:45 am]

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

[50 CFR Part 17]

ENDANGERED AND THREATENED WILDLIFE AND PLANTS

Proposed Determination of Critical Habitat for Six Butterflies and Two Plants

The Director, United States Fish and Wildlife Service (hereinafter, the Director and the Service, respectively) hereby issues a Proposed Rulemaking which would determine Critical Habitat for the Lotis Blue Butterfly (*Lycaeides argyrognomon lotis*), Lange's Metalmark Butterfly (*Apodemia mormo langei*), San Bruno Elfin Butterfly (*Callophrys mossii bayensis*), Mission Blue Butterfly (*Icaricia icarioides missionensis*), Smith's Blue Butterfly (*Shijimiaeoides enoptes smithi*), El Segundo Blue Butterfly (*Shijimiaeoides battoides allyni*), Contra Costa Wallflower (*Erysimum capitatum* var. *angustatum*), and the Antioch Dunes Evening Primrose (*Oenothera deltoides* ssp. *howellii*). This Proposal is issued pursuant to Section 7 of the Endangered Species Act of 1973 (16 U.S.C. 1531–1543; 87 Stat. 884; hereinafter the Act).

BACKGROUND

All eight species herein considered are denizens of coastal California and are species whose habitats have been severely impacted by man's activities. For the butterflies, maintenance of sufficiently large areas containing their caterpillar food plants and adult nectar plants is necessary for their continued survival. For the plants, maintenance of sufficiently large areas with proper soil type and exposure and sufficiently large areas to maintain populations of the appropriate insect pollinators is necessary. The Service recognizes that areas containing such sites may qualify for recognition as Critical Habitat as referred to in section 7 of the Act.

The areas delineated below are known to have been populated by these insects and plants in recent years or are known to contain significant populations of the insect's caterpillar food plants. It is emphasized that these areas may not represent all of what may be the overall Critical Habitat of these species in the United States, and additional areas may be proposed for designation in the future.

Information which enabled delineation of the Critical Habitat zones proposed herein was derived from the personal knowledge of Dr. Paul A. Opler (Staff Biologist, FWS/OES), published scientific papers, and an unpublished report prepared for the California Department of Food and Agriculture by Mr. Julian Donahue (National History Museum of Los Angeles County).

EFFECTS OF THE RULEMAKING

The effects of this determination are involved primarily with Section 7 of the Act, which states:

> The Secretary shall review other programs administered by him and utilize such programs in furtherance of the purposes of this Act. All other Federal departments and agencies shall, in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species listed pursuant to section 4 of this Act and by taking such action necessary to insure that actions authorized, funded, or carried out by them do not jeopardize the continued existence of such endangered species and threatened species or result in the destruction or modification of habitat of such species which is determined by the Secretary, after consultation as appropriate with the affected States, to be critical.

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An interpretation of the term "Critical Habitat" was published by the Fish and Wildlife Service and the National Marine Fisheries Service in the FEDERAL REGISTER of April 22, 1975 (40 FR 17764-17765). Some of the major points of that interpretation are: (1) Critical Habitat could be the entire habitat of a species, or any portion thereof, if any constituent element is necessary to the normal needs or survival of that species; (2) actions by a Federal agency affecting Critical Habitat of a species would not conform with Section 7 if such actions might be expected to result in a reduction in the numbers or distribution of that species of sufficient magnitude to place the species in further jeopardy, or restrict the potential and reasonable recovery of that species; and (3) there may be many kinds of actions which can be carried out within the Critical Habitat of a species which would not be expected to adversely affect that species.

This last point has not been well understood by some persons. There has been widespread and erroneous belief that a Critictal Habitat designation is something akin to establishment of a wilderness area or wildlife refuge, and automatically closes an area to most human uses. Actually, a Critical Habitat designation applies only to Federal agencies, and essentially is an official notification to these agencies that their responsibilities pursuant to Section 7 of the Act are applicable in a certain area.

A Critical Habitat designation must be based solely on biological factors. There may be questions of whether and how much habitat is critical, in accordance with the above interpretation, or how to best legally delineate this habitat, but any resultant designation must correspond with the best available biological data. It would not be in accordance with the law to involve other motives; for example, to enlarge a Critical Habitat delineation so as to cover additional habitat under section 7 provisions, or to reduce a delineation so that actions in the omitted area would not be subject to evaluation.

There may indeed be legitimate questions of whether, and to what extent, certain kinds of actions would adversely affect listed species. These questions, however, are not relevant to the biological basis of Critical Habitat delineations. Such questions should, and can more conveniently, be dealt with after Critical Habitat has been designated. In this respect, the Service in cooperation with other Federal agencies has drawn up a set of guidelines which, in part, establish a consultation and assistance process for helping to evaluate the possible effects of actions on Critical Habitat.

PUBLIC COMMENTS SOLICITED

The Director intends that the rules finally adopted be as accurate as possible in delineating the Critical Habitats of the Lotis Blue Butterfly, Lange's Metalmark Butterfly, San Bruno Elfin Butterfly, Mission Blue Butterfly, Smith's Blue Butterfly, El Segundo Blue Butterfly, Contra Costa Wallflower, and the Antioch Dunes Evening Primrose. The Director, therefore, desires to obtain the comments and suggestions of the public, other concerned governmental agencies, the scientific community, or any other interested party on these Proposed Rules.

Final promulgation of Critical Habitat regulations will take into consideration the comments received by the Director. Such comments and any additional information received may lead the Director to adopt final regulations that differ from this Proposal.

ENVIRONMENTAL ASSESSMENT

An environmental assessment, prepared in conjunction with this proposal, is on file in the Service's Office of Endangered Species, 1612 K Street, N.W., Washington, D.C. 20240, and may be examined there during regular business hours. A determination will be made at the time of final rulemaking as to whether this is a major Federal action which would significantly affect the quality of the human environment within the meaning of Section 102(2)(C) of the National Environmental Policy Act of 1969.

SUBMITTAL OF WRITTEN COMMENTS

Interested persons may participate in this Rulemaking by submitting written comments preferably in triplicate, to the Director (FWS/WPO), U.S. Fish and Wildlife Service, Department of the Interior, Washington, D.C. 20240. All relevant comments received no later than April 8, 1977, will be considered. The Service will attempt to acknowledge receipt of comments, but substantive responses to individual comments may not be provided. Comments received will be available for public inspection during normal business hours at the Service's Office in Room 514, 1717 H Street, N.W., Washington, D.C.

Dated: January 21, 1977.

LYNN A. GREENWALT,
Director,
Fish and Wildlife Service.

Accordingly, it is hereby proposed to amend 50 CFR Part 17:

1. By amending the table of sections for Subpart I of Part 17 to read as follows:

Subpart I—Interagency Cooperation

Sec.
17.95 Critical Habitat.
17.96 Plants.

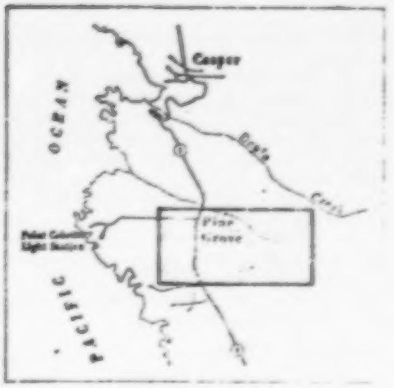
2. By adding new § 17.95(i), 1-6 and § 17.96, a and b reading as follows:

§ 17.95 **Critical habitat.**

* * * * *

(i) *Insecta.*—(1) *Lotis Blue Butterfly.* The following area is Critical Habitat for the Lotis Blue Butterfly (*Lycaeides argyrognomon lotis*):

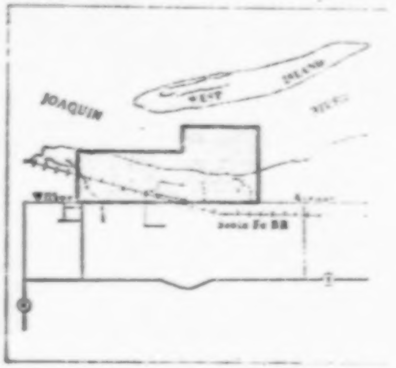
California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in Mendocino County with the following components: T17N R17W SW¼ of Sec. 7, SE¼ of Sec. 12.



PROPOSED CRITICAL HABITAT FOR LOTIS BLUE BUTTERFLY

(2) *Lange's Metalmark Butterfly.* The following area is Critical Habitat for the Lange's Metalmark Butterfly (*Apodemia mormo langei*):

California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in Contra Costa County with the following components: T2N R2E SW¼ Sec. 17, E½ of S½ Sec. 18.



PROPOSED CRITICAL HABITAT FOR LANGE'S METALMARK BUTTERFLY

(3) *San Bruno Elfin Butterfly.* The following area is Critical Habitat for the San Bruno Elfin Butterfly (*Callophrys mossii bayensis*):

California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in San Mateo County with the following components: all that portion of the San Bruno Mountains (excluding Cypress Hills Golf Course, Olivet Memorial Park, Hillside School and Colma School) bounded by a line extending along Guadalupe Canyon Expressway from its junction with Hillside Boulevard to its junction with Radio Road, thence along Radio Road to its terminus, thence southeastwardly along an unimproved dirt road which runs down the highest ridge of the mountains for about two miles to its intersection with a triple-pole power-line, thence southwardly along the power-line right-of-way to its intersection with Randolph Avenue to its intersection with Hillside Boulevard, thence northwestwardly along Hillside Boulevard to its intersection with Guadalupe Canyon Expressway.

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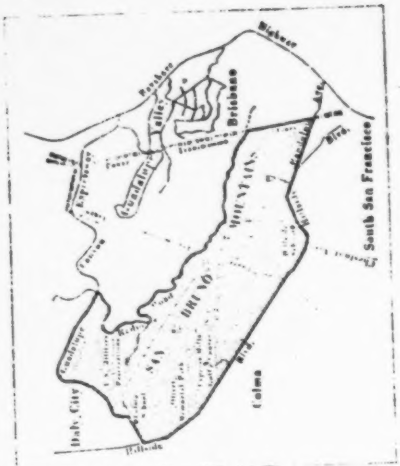
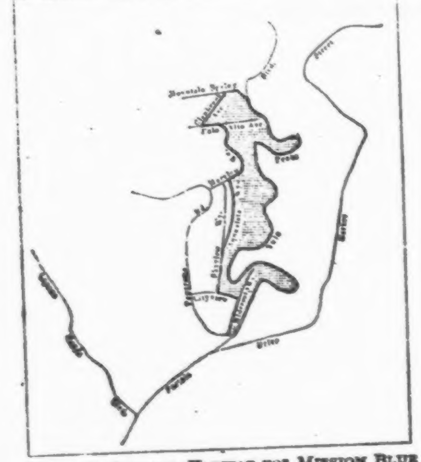


PROPOSED CRITICAL HABITAT FOR SAN BRUNO ELFIN BUTTERFLY

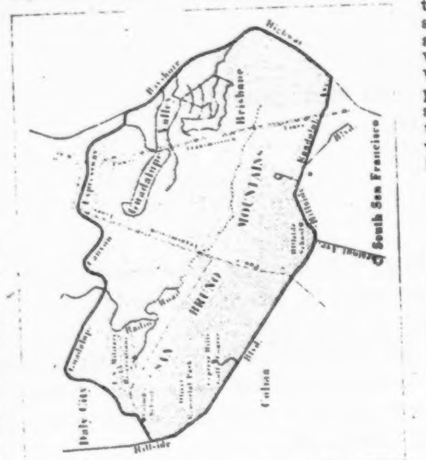
(4) *Mission Blue Butterfly*. The following areas are Critical Habitat for the Mission Blue Butterfly (*Icaricia icarioides missionensis*):

California—Twin Peaks Zone: An area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in San Francisco County, with the following components: an area bounded by a line extending from the junction of Mountain Spring Street and Twin Peaks Boulevard southwardly along Twin Peaks Boulevard to its junction with Panorama Road, thence westwardly along Panorama Road to its junction with Midcrest Way, thence northeastwardly along Midcrest Way to its junction with Cityview Way, thence westwardly along Cityview Way to its junction with Skyview Way, thence northwardly along Skyview Way to its junction with Aquavista Way, thence northwardly along Aquavista Way to its junction with Marview Way, thence northwardly along Marview Way to its junction with Palo Alto Avenue, thence westwardly along Palto Alto Avenue to its junction with Glenbrook Avenue, thence northeastwardly along Glenbrook Avenue to its junction with Mountain Spring Street, thence eastwardly along Mountain Spring Street to its junction with Twin Paks Boulevard.



PROPOSED CRITICAL HABITAT FOR MISSION BLUE BUTTERFLY (Twin Peaks Zone)

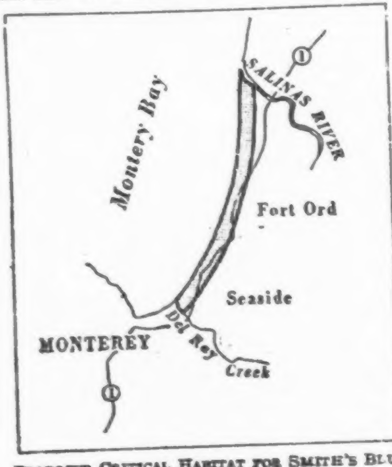
San Bruno Mountains Zone: An area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in San Mateo County, with the following components: an area enclosed within a line extending from the junction of Guadalupe Canyon Expressway and Bayshore Highway, thence southwardly along Bayshore Highway to Randolph Avenue, thence northwestwardly along Randolph Avenue to its junction with Hillside Boulevard, thence northwestwardly along Hillside Boulevard to its junction with Guadalupe Canyon Expressway, thence eastwardly along Guadalupe Canyon Expressway to its junction with Bayshore Highway.



PROPOSED CRITICAL HABITAT FOR MISSION BLUE BUTTERFLY (SAN BRUNO MOUNTAINS ZONE)

(5) *Smith's Blue Butterfly*. The following area is Critical Habitat for the Smith's Blue Butterfly (*Shijimiaeoides enoptes smithi*):

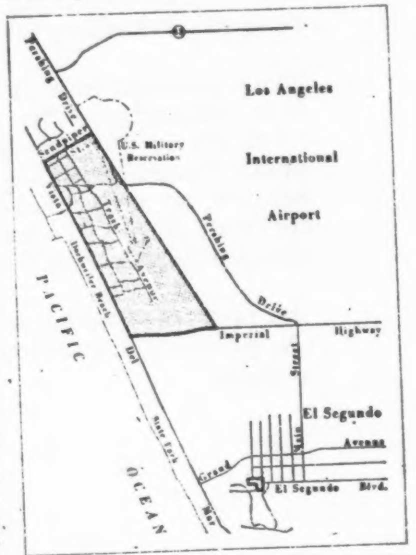
California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in Monterey County with the following components: an elongate strip of coastal sand dunes, extending one kilometer inland in a westward direction from the Pacific Ocean (mean higher high tide line), bounded by Del Rey Creek on the south and the Salinas River on the north.



PROPOSED CRITICAL HABITAT FOR SMITH'S BLUE BUTTERFLY

(6) *El Segundo Blue Butterfly*. The following areas are Critical Habitat for the El Segundo Blue Butterfly (*Shijimiaeoides baltoides allyni*):

California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in Los Angeles County, with the following components: (1) An area to the east of Los Angeles International Airport bounded by a line extending from the junction of Vista Del Mar and Sandpiper Street westwardly along Sandpiper Street to its junction with Pershing Drive, thence southwestwardly along Sandpiper Street to its tion to the junction of Imperial Highway and Hillcrest Street, thence westwardly along Imperial Highway to its junction with Vista Del Mar, thence northwestwardly along Vista Del Mar to its juunction with Sandpiper Street; (2) A two-acre area of natural sand dune to the south of and abutting the western terminus of EL Segundo Boulevard (118°25'0" W Long., 33°55'0" N Lat.) in El Segundo.



PROPOSED CRITICAL HABITAT FOR EL SEGUNDO BLUE BUTTERFLY

§ 17.96 Plants.

(a) Contra Costa Wallflower. The following area is Critical Habitat for the Contra Costa Wallflower (*Erysimum capitatum* var. *angustatum*):

California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in Contra Costa County, with the following components: T2N R2E SW¼ Sec. 17, E⅔ of S⅓ Sec. 18.

(b) Antioch Dunes Evening Primrose. The following area is Critical Habitat for the Antioch Dunes Evening Primrose (*Oenothera deltoides* ssp. *howellii*):

California—an area of land, water, and airspace (exclusive of those existing manmade structures or settlements which are not necessary to the survival or recovery of the species) in Contra Costa County, with the following components: T2N R2E SW¼ Sec. 17, E⅔ of S⅓ of Sec. 18.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
WASHINGTON, D.C. 20240

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

In Reply Refer To:
FWS/OES Sp

Ms. Linda Ford McCaffrey
Daniel, Mann, Johnson and Mendenhall
3250 Wilshire Boulevard
Los Angeles, CA 90010

Dear Ms. McCaffrey:

Thank you for your letter of August 16, concerning the El Segundo Blue Butterfly. The federally proposed critical habitat was withdrawn on March 6, 1979 (Federal Register, Vol. 44, No. 45: 12382). As staff entomologist, I am responsible for reproposing the critical habitat to meet the requirements of the Endangered Species Act Amendments of 1978. I cannot give a precise estimate of a date for final designation of critical habitat.

The butterfly remains federally designated as Endangered and retains the protection provided by the Endangered Species Act of 1973, as amended.

Sincerely,

Michael M. Bentzien
Staff Entomologist
Office of Endangered Species

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

APPENDIX B3

SUMMARY OF MARINE RESOURCE EVALUATIONS

Ocean disposal of sludge is provided by three of the twelve alternative sludge management projects anayzed by LA/OMA Project. Under the Baseline "No Project" Alternative, sludge dewatering capacity is assumed to be constant at levels existing or committed to as of December 31, 1978. Liquid digested sludge in excess of such capacity was assumed to be discharged to the ocean via existing submarine outfall systems.

Under the Deep Ocean Disposal Project, new sludge only submarine outfalls would be constructed for each operating agency to terminate in ocean waters at about 1,000 feet in depth. Each agency would discharge all screened digested sludge to the ocean via these new outfalls. Alternatively, Barge Disposal was included and (rather than construct new outfalls), liquid screened digested sludge would be pipelined to a dock in the Los Angeles-Long Beach Harbor complex. Liquid sludge would be dispersed over the ocean by discharge through a pipe trailing the barge at 150 depth. Area of discharge would be about 60 miles from shore.

All of the above projects assume full secondary treatment of wastewater will be provided.

Ocean disposal of sludge is a topic of major interest. Historically, there have been differing viewpoints regarding the extent and significance of environmental concerns and documented effects associated with ocean disposal. Current Federal statutes and regulations and the California State Ocean Plan prohibit disposal of sludge in ocean waters.

The task of measuring impacts from specific sources in open coastal waters is substantial. Of necessity conclusions must be drawn from available data. The information in this report has been drawn from a wide variety of sources as can be seen from the list of references provided at the end of the report. LA/OMA Project contracted with the Southern California Coastal Water Research Project (SCCWRP) to prepare task reports which described conditions existing around the LA/OMA outfalls and which provided forecasts of probable marine impacts under the Baseline Alternative. Dr. John R. Calaprice was retained by LA/OMA Project to prepare a concise summary of the SCCWRP findings and to provide information on effects which are described in other literature. To supplement this information, reports in the list of references were consulted.

It is recognized that new information is a continuing phenomenon, particularly in the area of marine biology. The marine environment is not static and changes are being made in man's operations which affect the ocean. The attached summary seeks to provide information at a set point in time which is consistent with the requirement for a decision regarding sludge management alternatives.

The following information is organized as follows:

- Input of Pollutants to the Bight

  Discussion of sources of pollutant discharges to the Southern California Bight. Includes discussion of municipal discharges.

- Marine Water Quality and Sediments

  Review of information on quality of waters in the Southern California Bight and sediment characteristics in outfall and control areas.

- Marine Biotic Setting

  Classification of the marine environment; description of the function and interrelationships of water column, benthic, and air/water interface environments and communities.

- Effects of Existing Outfall Systems

  Summary of potential and measured physical, chemical and biological responses to marine waste disposal.

- Potential Impact on Marine Biotic Resources From Alternative Sludge Management Projects Involving Ocean Disposal.

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INPUT OF POLLUTANTS TO THE BIGHT

- OVERVIEW OF FINDINGS
- ANALYSIS OF CONTRIBUTING MECHANISMS

INPUT OF POLLUTANTS TO THE BIGHT

As a matter of perspective, it is helpful to visualize the collective and individual pollutant contributions of Southern California Bight sewage discharges in relation to estimated contributions from other sources. Sewage constituents which may affect the quality of local receiving waters and biotic communities include many kinds of chemical elements such as heavy metals, compounds such as DDT and PCBs, ions, radioactive isotopes, inert solids, heat, bacteria, and viruses. Sources of these contaminants can be conveniently classified as either:

- discrete - includes municipal discharges, industrial wastes, and surface runoff via rivers, streams, storm drains, and creeks, or
- diffuse - includes vessel operations, ocean dumping, aerial fallout, and advective transport by ocean waters.

Unfortunately, the most recent attempt to characterize the input of pollutants from all these sources during roughly the same period was carried out in 1971-72. Improvements in industrial waste pretreatment and source control or municipal wastewater treatment practice may have influenced the relative magnitudes of specific inputs since that time. Selective measurements since 1972 tend to show that this is the case. Estimated mass emission rates for inputs (excluding chlorinated hydrocarbons) to the Southern California Bight in 1971-72 are listed in Table 1. The relative mass emission rates of total DDT and PCBs (polychloriated biphenyls) are illustrated in Table 2. Reductions shown in the time-dependent efflux of total DDT in local municipal discharges are primarily due to implementation of source control measures by the lone manufacturer of DDT in the Los Angeles Basin, whose wastes had contributed to the JWPCP flow.

OVERVIEW OF FINDINGS

Most of the data presented in this section represent one-time survey results, as opposed to a regular monitoring program. Because of the lack of verification and enormous variation which might be expected in measurements of this sort, this material should be used with caution. Nevertheless, it is felt that the following statements and conclusions can be supported on the basis of data provided in Tables 1 and 2. For the period 1971-72:

- The contribution of suspended solids from municipal discharges was roughly equivalent to that of silt loadings. However, the organic fraction of sewage solids is much higher than that of silts. (Ref. 501.)
- Municipal discharges dominated all other sources (except perhaps advective transport in the ocean) in terms of cadmium, chromium, nickel, and silver contributions to the Southern California Bight. (Ref. 501.)
- Municipal discharges, vessel operations (use of antifouling paint) and aerial fallout (direct rainfall) were found to contribute copper and mercury at similar rates. (Ref. 501.)

TABLE 1

ESTIMATED ANNUAL INPUTS TO THE SOUTHERN CALIFORNIA BIGHT EXCLUDING CHLORINATED HYDROCARBONS
1971-72

(Metric Tons per Year)

Constituent	Discrete Sources			Diffuse Sources				TOTAL
	Municipal Discharges	Surface Runoff	Industrial Waste	Vessel Operations	Ocean Dumping	Aerial Fallout	Advective Transport	
Silt	-	274,000	-	-	-	-	-	274,000
Total Suspended Solids	278,000	-	16,000	-	-	-	-	294,000
Volatile Suspended Solids	179,000	-	-	-	-	-	-	179,000
5-day Bio. Oxygen Demand	291,000	-	6,000	-	-	-	-	297,000
Chemical Oxygen Demand	675,000	29,000	78,000	-	-	-	-	782,000
Oil and Grease	65,000	4,400	2,200	-	-	-	-	71,600
Dissolved Silica (SiO_2)	33,000	2,800	-	-	-	-	-	35,800
Nitrate Nitrogen	530	980	-	-	-	-	-	1,510
Ammonia Nitrogen	59,400	440	9,500	-	-	-	-	69,340
Organic Nitrogen	24,800	1,090	-	-	-	-	-	25,890
Total Nitrogen	85,400	2,510	10,000	-	-	-	-	97,910
Phosphate Phosphorous	13,300	410	-	-	-	-	-	13,710
Detergent (MBAS)	7,600	66	-	-	-	-	-	7,666
Cyanide (CN)	210	11	-	-	-	-	-	221
Phenols	1,730	269	43	-	-	-	-	2,042
Heat (10^9 kwh/yr)	-	-	94	-	-	-	-	94
Silver	15	1.1	-	-	1.5	-	6,000	6,018
Arsenic	-	-	-	1.5	-	-	-	2
Cadmium	54	1.2	-	0.1	14	-	2,000	2,069
Cobalt	3.0	5.3	-	-	14	-	8,000	8,022
Chromium	649	25	-	1.0	28	-	4,000	4,703
Copper	567	18	-	386	28	400	60,000	61,399
Mercury	2.9	0.06	-	3.9	1.5	8	600	616
Nickel	313	17	-	-	28	40	140,000	140,398
Lead	211	90	-	9.5	28	3,400	6,000	9,738
Zinc	1,680	101	-	164	56	2,200	200,000	204,201
Iron	6,000	26,000	-	-	200	40	60,000	92,320
Manganese	102	183	-	-	28	400	40,000	40, 793

Source: "The Ecology of the Southern California Bight: Implications for Water Quality Management", SCCWRP, (March 1973).

TABLE 2

ESTIMATED ANNUAL INPUT OF DDT AND PCB TO THE SOUTHERN CALIFORNIA BIGHT

(Metric tons per year)

Source	Year	Total DDT	1242 PCB	1254 PCB
Municipal Discharges	1971	21.6(a)		
	1972	6.5	≥19.2	≥0.3
	1973	3.9	≥ 1.9	1.5
	1974	1.6	4.3	1.0
	1975	1.3	2.4	0.7
	1976	1.3	2.2	0.6
Harbor Industries	1973-74	0.04	< 0.07	0.03
Vessel Operations(b)	1973	<0.01	< 0.01	<0.01
Surface Runoff	1971-72	0.1	0.1-0.2	0.01
	1972-73	0.3	0.0-0.6	0.3
Aerial Fallout(c)	1973-74	1.4		1.1
Advective Transport(d)	1973	≤7		≤4

Source: "Report on Task 2 - Describe Existing Conditions" - Task Report to LA/OMA Project, SCCWRP, (September 19, 1977).

(a) Total discharge of DDT by Los Angeles County Sanitation Districts' Joint Water Pollution Control Plant.
(b) Antifouling paint used for vessel protection.
(c) Based upon surface area of 400 km x 50 km (intercoastal zone)
(d) Ocean currents

- Municipal discharge and aerial fallout (direct rainfall) appeared to be the predominant sources of zinc, again excluding ocean current advection as a potential source. (Ref. 501.)

- Trace metals in municipal wastewaters are primarily associated with sewage particulates. For seven of the metals studied (cadmium, copper, chromium, iron, lead, silver, and zinc), about 90 percent of the total metal content of municipal discharges was found to be associated with particulate material retained on a 0.45 micron filter. (Ref. 501.)

- Surface runoff contributed greater amounts of iron, manganese, and cobalt than did municipal discharges. (Ref. 501.)

- Aerial fallout was found to contribute an order of magnitude more lead than did municipal discharge and surface runoff combined. (Ref. 501.)

The meaning of these data and observations, assuming they are accurate estimators of Bight-wide annual inputs, should not be over-emphasized. Processes which tend to concentrate pollutants in biological compartments (such as sedimentation coupled with retention of metals and chlorinated hydrocarbons on particulates) appear to offer the most serious ecological problems. Although the overall contributions of aerial fallout and especially advective transport are large for some pollutants, these inputs are generally quite diffuse and seldom lead to unacceptably high local concentrations of these pollutants in the environment.

ANALYSIS OF CONTRIBUTING MECHANISMS

In material which follows, each of the primary sources of pollutants to waters of the Southern California Bight is examined in turn.

Advective Transport

Large quantities of substances are routinely transported through the Bight by the California current. While extremely low concentrations of pollutants are normally found in these waters, the current's massive flow--on the order of 14,000,000 mgd--results in large theoretical mass flow rates. However, the problem of estimating the advective transport of these same materials out of the Bight has not yet been approached. Changes in the concentrations of trace constituents in California current waters would probably defy measurement.

Surface Runoff

Stream runoff is a function of both the regional hydrology and the regulation provided by dams and other water management systems. Within the Southern California coastal basin there are more than 150 streams discharging intermittently at points along the coastline. Nineteen streams and rivers drain approximately 70 percent of the coastal basin. In addition to the natural streams, there are between 50 and 150 major storm drains which discharge to coastal waters. (Ref. 501.)

Data representing stream runoff in Table 1 were collected during an abnormally dry year and, as a consequence, underestimate average annual contributions from that source. As a practical matter, the most significant effects attributable to storm flow are generally associated with the first significant storm of the wet season (first flush). Similar to wastewater discharges, the major fraction of trace metals and chlorinated hydrocarbons in surface runoff is associated with particulate material. Data collected in April 1973 indicated that the highest concentrations of trace metals in urban runoff were found on suspended particulates in channels of the Los Angeles/Orange County Metropolitan Area (Ballona Creek, Los Angeles River, Dominguez Channel). (Ref. 504.)

Surface runoff can also result in elevated coliform concentrations in nearshore marine waters. This trend was observed by the City of Los Angeles at shore sites near Ballona Creek and has been reported in the vicinity of Orange County streams. Table 3 represents a summary of total coliform and enteric virus concentration measurements reported by SCCWRP at local shore stations in 1975-76. These data appear to confirm the suspected role of Ballona Creek as a source of bacterial contamination. (Ref. 504.)

Aerial Fallout

With the exception of lead, iron, and manganese, aerial fallout of trace metals to the Southern California Bight is of secondary importance relative to the contributions of municipal discharges. (Ref. 504.)

It is possible to estimate the volume of specific, environmentally significant chlorinated hydrocarbons added to the Bight each year via aerial fallout to each of a series of geographical sectors chosen arbitrarily along the Southern California coast. The sectors developed for this purpose are shown in Figure 1. Identifiers are provided which correspond to sector codes in Table 4. The table contains recently (1975) estimated rates of fallout of chlorinated hydrocarbons into nearshore waters under the influence of Santa Ana and non-Santa Ana winds. The estimated annual contributions attributable to aerial fallout are based upon the weighted average (by duration) of fallout rates corresponding to these two wind conditions. The exaggerated rates of addition which accompany the Santa Ana condition arises because these winds sweep across the Los Angeles Basin, usually during extremely arid periods, prior to passing over local coastal waters. (Ref. 504.) The Bight-wide annual aerial fallout of DDT predicted via these means exceeds the estimated contribution of DDT from the five major municipal dischargers over the same period. The aerial fallout of PCBs is about equivalent to the combined mass emission rate from these discharges. However, if one focuses on Sectors E, F, and G (see Figure 1), the area most immediately influenced by LA/OMA municipal discharges, the 1977 mass emission rate (MER) of DDT from LA/OMA dischargers (0.7 metric tons per year) slightly exceeds the corresponding estimating aerial contribution, and the 1977 MER of PCBs (1.5 metric tons per year) is about 3 times as great as the aerial fallout of PCBs to these sectors. It seems plain that if smaller areas surrounding the LA/OMA outfalls were isolated in this manner, the relative contributions of municipal dischargers would become locally more significant.

Ocean Dumping

In the past, ocean dumping has been used for disposal of refinery wastes, chemical wastes, oil drilling wastes, filter cake, refuse and garbage, radioactive

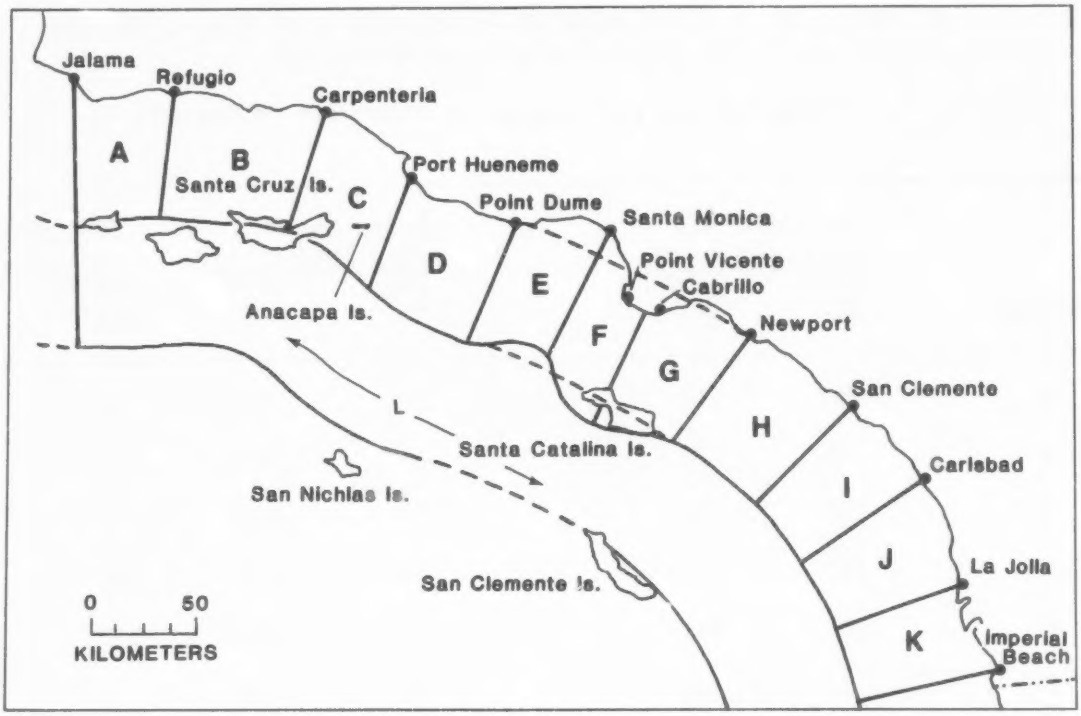
TABLE 3

TOTAL COLIFORM BACTERIA AND ENTEROVIRUS IN MUSSELS FEBRUARY 1975 to JUNE 1976

Date	Location	Total Coliform MPN/kg	Enterovirus PFU/kg
Shore Collections			
Feb. 1975	Marina del Rey Yacht Channel	N.A.	Detected
Feb. 1975	Ballona Creek	2.5×10^6	Detected
June 1975	Ballona Creek	4.2×10^6	0
Sept 1975	Royal Palms	$<2 \times 10^2$	0
Aug. 1975	Royal Palms	8.6×10^4	0
Sept 1975	Marina del Rey Coast Guard Dock	1.3×10^4	0
30 Sept 1965	Dey Rey Lagoon	1.7×10^3	0
Dec. 1975	Abalone Cove, P.V.	2.6×10^4	0
8 Dec. 1975	Royal Palms	6.9×10^4	0
Control			
23 Apr. 1976	Scotchman's Cove Laguna	$<2 \times 10^2$	0
July 1975	Platform Hazel	$<2 \times 10^2$	0
Feb. 1976	Platform Hazel	$<2 \times 10^2$	0

Source: "Report on Task 2, Describe Existing Conditions", Task Report to LA/OMA Project, SCCWRP, (September 29, 1977).

Note: Samples taken from digestive glands of the mussels.



SOURCE:

Young, D.R., T.C. Heesen and D.J. McDermott. "Synoptic Survey of Chlorinated Hydrocarbon Inputs to the Southern California Bight". Report for EPA, Grant No. R803707, (1977), as reported in Reference No. 504.

COLLECTION STATIONS AND SECTORS FOR AERIAL FALLOUT SURVEYS

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 1

TABLE 4

ESTIMATED INPUT OF CHLORINATED HYDROCARBON FROM AERIAL FALLOUT TO THE SOUTHERN CALIFORNIA BIGHT

(Kilograms per year except as otherwise indicated)

	Non-Santa Ana Wind Conditions		Santa Ana Wind Conditions		Estimated Annual MER	
Sector	Total DDT	1254 PCB	Total DDT	1254 PCB	Total DDT	1254 PCB
A	38	52	97	72	52	57
B	64	73	160	140	88	90
C	100	82	300	180	150	110
D	120	98	350	210	180	130
E	100	110	200	160	120	120
F	81	82	200	140	110	97
G	140	97	630	310	260	150
H	90	86	410	190	170	110
I	67	69	270	140	120	87
J	51	70	100	110	63	80
K	31	54	130	110	55	68
Inner Total	880	870	2,800	1,800	1,400	1,100
L	270	630	1,000	720	450	650
Grand Total	1,200	1,500	3,800	2,500	1,800	1,800
Grand Total (MT/Yr)	1.2	1.5	3.8	2.5	1.8	1.8

Source: Young, D.R., Heesen, T.C., McDermott, D.J., "Synoptic Survey of Chlorinated Hydrocarbon Inputs to the Southern California Bight". Report for EPA, Grant No. R803707, (1977). As provided in Reference No. 504.

wastes, military explosives, and miscellaneous other wastes. Fourteen sites have been utilized within the Bight. All sites are now inactive. (Ref. 502.)

Vessel Operations

Ocean vessel operations contribute trace contaminants to the marine environment because of their inclusion in antifouling paints, zinc anodes (to provide cathodic protection), and fuels. With the exception of copper and mercury, 1971-72 data (Table 1) indicate that vessel operations do not result in a significant contribution of metals relative to other bight-wide inputs. (Ref. 501.) Elimination of PCBs from antifouling paint has eliminated vessel operations as a potential source of these pollutants in the marine environment although such paints may have been a significant source in the past (Ref. 512).

Direct Industrial Discharges

Direct industrial discharges may be conveniently classified as belonging to one of three broad groups: (1) plants for generation of electrical power, (2) industries discharging directly to coastal waters, and (3) industries discharging to San Pedro Bay.

Data collected by SCCWRP on trace metals in influents and effluents from eight Southern California Edison coastal power plants indicate that passage of seawater through coastal power plants add insignificant amounts of trace metals to coastal waters. (Ref. 504.) On the other hand, significant, ecological effects can result from thermal properties of such discharges. Local Edison data from 1973-74 indicate that the volume of seawater used daily as coolant would cover an area of 12 square miles to a depth of one foot. The entrapment of marine organisms in local cooling water intakes alone was responsible for the daily destruction of approximately 1000 pounds of fish, or about 0.1 percent of the commercial fish landed in South Coast waters. Other forms of marine life were undoubtedly destroyed in the process. Thermal wastes increased the ambient surface water temperature by 4° F or more over a combined area of almost two square miles. According to the State Department of Fish and Game, temperatures in excess of 66° F can arrest the growth of giant kelp and lead to sloughing. Over an extended period, such elevated temperatures can cause permanent damage (Ref. 567).

Excluding power plants, the largest single industrial discharger from the Orange and Los Angeles County Metropolitan Area wasting directly to the coastal waters of the Bight is the El Segundo Refinery which discharges 72 mgd of cooling water and refinery waste to Santa Monica Bay. South of Whites Point and exclusive of the harbor area, direct discharges consist mainly of oil brines from petroleum production facilities. Other direct discharges to coastal waters of the Bight are small and almost entirely associated with petroleum production. (Ref. 501.)

The largest concentration of direct industrial sources lies in the San Pedro Bay area and discharges to the Los Angeles/Long Beach Harbor and associated tidal prisms. Due to the affinity of heavy metals for particulates, pollutants discharged into the San Pedro Bay area frequently settle inside the harbor and do not reach open coastal waters. Direct measurement of net exchange of trace metals or potentially harmful chemicals during a tidal cycle is difficult, and reliable data are generally lacking. However, SCCWRP has concluded that only small differences exist between concentrations of chlorinated hydrocarbons in outflowing and inflowing tidal phases. The net efflux of metals from the harbor area was estimated to be an order of magnitude lower than the combined inputs of municipal sewage discharges. On the basis of total emissions, the harbor area appears to be a relatively unimportant source of toxic substances to the coastal environment (Ref. 516).

Oil is a potential marine pollutant which, for want of a more appropriate area, will be discussed among the effects attributable to industrial discharges. Oil can enter marine waters via accidents or spills associated with offshore drilling operations, tanker movements, and deballasting. Other sources of oil in the marine environment include sewage discharge, runoff, and natural seeps. Apart from smothering, the degree of damage sustained among marine organisms is dependent upon factors such as where the oil is released, the type of oil involved and its degree of refinement, and wind and wave conditions. In general, near-shore waters, enclosed bays, and estuaries are more susceptible to serious damage. The area within and immediately surrounding the Los Angeles/Long Beach Harbor is of particular concern in light of the numerous oil production and distribution activities in that region (Ref. 567).

LA/OMA Municipal Discharges

In 1977 the total volume of municipal wastewater discharged to the Southern California Bight was slightly in excess of one billion gallons per day. Five systems (Los Angeles County Sanitation Districts, City of Los Angeles, Orange County Sanitation Districts, City of San Diego, and Oxnard) accounted for 96 percent, and municipal dischargers from the Orange/Los Angeles County Metropolitan Area for 84 percent of the total (Ref. 515). Sewage treatment and disposal facilities operated by the LA/OMA agencies (summarized elsewhere) accounted for perhaps 90 percent of the potentially harmful sewage constituents discharged to the Southern California Bight in 1977. Implementation of planned treatment process improvements among these facilities will improve this balance from the standpoint of the LA/OMA agencies.

Although much is said about their role as determinants of environmental quality elsewhere in this report, a brief review of sewage constituents which have contributed to local marine ecological perturbations is appropriate here.

- Particulates: Physical environmental factors such as currents and degree of stratification in the receiving water help determine the distribution of particulates of sewage origin in the marine environment. It is generally estimated that less than 10 percent of the particulate mass in the Palos Verdes discharge (which has historically contained a large volume of anaerobically digested solids) settle out of the sewage/seawater mixture, which results from initial dilution, in the vicinity of the outfall system (within about 10 kilometers). Despite the relatively low percentage of particles which reach the local sediments, the discharge of sludge solids from deep ocean outfalls is likely to produce changes in the physical and biological characteristics of the surrounding sediments. Benthic effects are due both to the locally elevated rate of particulate flux and the organic nature of sewage and sludge solids (Ref. 564).

- Nutrients: These substances are required by marine organisms for growth. The primary macronutrients necessary for organic production include nitrogen, phosphorus, carbon, and dissolved silica. Trace metals, at appropriate levels, are also essential to a healthy physical state and biological productivity. Examples of physiologically important metals include copper, cobalt, zinc, iron, manganese, boron, molybdenum, and selenium. Sources of nutrients in coastal waters of the Bight include land runoff, upwelling of nutrient-rich deep waters into the euphotic zone, and sewage discharge. With the possible exception of the late winter months, the supply of nitrogen is generally the limiting factor in phytoplankton productivity along most areas of the coast (within the euphotic zone--sunlight limits growth in deeper waters) (Ref. 501).

  The major source of nitrogen in coastal waters is upwelling. It has been estimated that in an average year 180,000 metric tons are introduced into the coastal euphotic zone between Point Conception and the Mexican border via this mechanism. Surface runoff provides an additional 1500 metric tons per year. Because both of these processes are seasonal and subject to significant annual variation, fluctuations in the availability of nitrogen, and thus primary productivity, should be expected in most Southern California coastal waters (Ref. 501).

  In contrast to this situation, municipal discharges tend to be a relatively constant, though local, source of nitrogen. SCCWRP has estimated that municipal wastewater discharge contributes 85,000 metric tons of nitrogen to the Southern California Bight annually. Consequently, on a local basis, wastewater can provide the dominant nutrient source. It should be recognized that receiving water stratification can trap the sewage plume below the euphotic zone. Under such circumstances, sewage nutrients are available only via vertical diffusion or upwelling (Ref. 501).

  Washout of atmospheric oxides of nitrogen provides an additional, potential (although not easily quantifiable) source of nitrogen in Southern California coastal waters (Ref. 501).

- Trace Organics: Chlorinated hydrocarbons, particularly DDT and PCBs, in receiving waters and sediments have been the focus of local environmental concern and several special studies. Data provided earlier as Table 2 represent the results of one such study. From the Table and previous discussion, it is evident that a decade ago municipal effluents comprised the principal source of chlorinated hydrocarbons input to the Southern California Bight. Source control of DDT among indirect industrial dischargers has proven effective, primarily because of the overwhelming contribution of a single industrial source which discharged to the Los Angeles County Sanitation Districts' Joint Water Pollution Control Plant until 1970. The elimination of this single input is responsible for the drastic reduction in the mass emission rate of DDT from JWPCP thereafter.

  Because the manufacture and use of PCBs in the Southern California area is considerably more widespread, source control measures have resulted in a less dramatic effect on mass emission from local municipal sewage treatment facilities. Nevertheless, the cumulative discharge of PCBs (mostly Arochlor 1242) from municipal sewage treatment facilities has decreased by an order of magnitude since 1972, possibly as a result of 1971 restrictions which permit PCB use within closed systems only (Ref. 512). Waste discharge continues to be the largest point source of PCBs and DDTs to the Bight.

The contribution of surface runoff to the total influx of chlorinated hydrocarbons to the Bight is of secondary importance to those of municipal discharges and aerial fallout (see previous discussion of these sources). Storm flow from the Los Angeles Basin contributes 85 to 95 percent of the Bight-wide inputs of total DDT and PCBs which are attributable to surface runoff (Ref. 512).

Although data are scarce, there are indications that DDT and PCBs account for less than 1-2 percent of the total halogenated hydrocarbons in local municipal sewage effluent (Ref. 514). In general, it appears that chlorinated benzenes are present in these waters at levels which are an order of magnitude greater than the sum of measurable DDT and PCBs (Ref. 513). Streams, urban runoff, and aerial fallout do not contribute significantly to the overall input of chlorinated benzenes to the Southern California Bight (Ref. 513).

In 1978, LA/OMA discharges were analyzed for 65 classes of toxic constituents including heavy metals, synthetic organics, and others which were established by EPA as "priority pollutants." Results of this one-time monitoring effort indicated that about 10 percent of the target trace organics were present in concentrations above 10 μg/l (ppb--the quantification limit) in the Orange County and City of Los Angeles marine discharges and 15 percent in the Los Angeles County effluent (Ref. 517).

- Trace Metals: Data provided as Table 5 indicate heavy metals associated with sewage-related particulates constitute the largest single input of this class class of contaminants to the Southern California Bight. Only for lead (which enters the atmosphere in large quantities with automobile exhaust) do dry aerial deposition and storm runoff have input rates of similar magnitude. The Los Angeles County Sanitation Districts, City of Los Angeles, and Orange County Sanitation Districts account for about 90 percent of the combined input of trace metals from municipal discharges to the Bight (Ref. 504.)

TABLE 5

COMPARISON OF ESTIMATED ANNUAL INPUTS OF TRACE METALS TO THE SOUTHERN CALIFORNIA BIGHT

(Metric Tons Per Year)

	1976 Wastewater: Total	1976 Wastewater: Particulate (a)	Dry Fallout (b) 1975	Storm Runoff (c) 1972-73	Thermal Discharge (d) 1977	Sum	W/W Partic. (percent)
Ag	18	20	0.06	2.6	--	23	78
Cd	42	45	0.84	2.8	0.3	29	65
Cr	500	593	6.6	60	0.6	660	76
Cu	460	507	31	42	2.1	760 (e)	60
Hg	2.3	2.6	---	0.4	---	3	77
Ni	180	307	12	41	0.7	360	50
Pb	180	190	240	210	0.8	640	28
Zn	980	1,060	150	240	1.8	1,450	68

Source: "Report on Task 2 - Describe Existing Conditions", Task REport to LA/OMA Project, SCCWRP, (September 29, 1977.)

(a) Based on mean "percent particulate" values in Table IA1 f.

(b) 100 km x 100 km off Los Angeles-Orange County Basin.

(c) Extrapolating flow-eighted results from 1971-72 survey.

(d) Southern California Edison cooling water (6.8 x 10^{12} 1/yr).

(e) Includes 180 m ton/yr Cu used in vessel antifouling paints.

MARINE WATER QUALITY AND SEDIMENTS

WATER QUALITY CHARACTERISTICS ●

SEDIMENT CHARACTERISTICS ●

Various natural processes affect the severity of biological impacts attributable to marine disposal of sewage and sewage sludge. As a result, consideration of temporal and spatial variation among selected natural characteristics of the marine environment is prerequisite to forecasting the ecological consequences of a specific disposal situation. That is, the response of a particular marine environment to the introduction of a specific waste is dependent not only upon the qualities of that waste but also upon physical, chemical, and biological characteristics of the receiving water. Understanding both the scope of variation among natural waters and the relationships between receiving water parameters and the efficacy of waste disposal is essential to estimation of environmental costs associated with marine sludge disposal alternatives. For that reason, a somewhat detailed review of the parameters and processes which affect (and are affected by) marine disposal of sewage sludge is provided below.

WATER QUALITY CHARACTERISTICS

Significant water quality characteristics include temperature and salinity (which together determine water density) and concentrations of selected macro-nutrients, dissolved oxygen, trace metals, and dissolved organic compounds. Concentrations of major inorganics sodium, potassium, magnesium, calcium, chloride, bromide, sulfate, and bicarbonate (which together comprise 99 percent of the dissolved minerals in seawater) are relatively constant. (Refs. 501, 523.) Although many kinds of organic compounds, including sugars, amino acids, various other organic acids, lipids, phenolic compounds, humic acids, and some halogenated hydrocarbons, occur naturally in seawater, for purposes of this discussion, synthetic chlorinated hydrocarbons comprise the organic compounds of interest.

Temperature, Salinity, and Density

The density of seawater is essentially a function of temperature and salinity. The magnitude of the vertical density gradient is the most important single variable affecting the equilibrium height of rise (level of neutral buoyancy) of initially buoyant jets in stratified receiving waters. If sufficient density variation exists in the receiving water column, the dilute sewage/seawater plume will be trapped below the water surface eliminating potential problems associated with shoreline pathogen concentration and aesthetic considerations. On the other hand, a highly stratified receiving water might compress the initial dilution process, severely limiting the degree of mixing initially possible. Rapid initial dilution associated with the rise of buoyant jets is relied upon to mitigate potential receiving water quality problems.

Salinity (a measure of the concentration of dissolved salts in seawater) is relatively constant throughout the open ocean. However, it can vary in coastal waters, primarily because of the inputs of freshwater from land or because of upwelling. As a result, densities among open waters are primarily a function of water temperature. Temperatures of coastal waters vary significantly more than those of deeper waters due to not only the relative shallowness but, to some extent, the addition of land runoff and seasonal upwelling.

In seawater of sufficient depth, there is often a layer of relatively light, warm water overlying a cold, denser water mass. The transition between these layers, known as the thermocline, is often quite sharp, leading to virtual isolation of surface waters from deeper masses. The upper layer, which is generally well mixed by wind and other surface processes, extends to depths of 10 to 50 meters in southern California waters. (Ref. 501.) The thermocline is generally strongest in summer and fall but is weak or absent during winter due to storms and wind-induced mixing processes.

Surveys reported by SCCWRP (Ref. 518) provide information on depth and seasonal temperature trends. Trends common within southern California waters follow:

- Temperatures in bottom waters at 20 m are influenced by surface phenomena throughout most of the year, cooling during the winter months and warming during summer. At 60- to 140-m depths, bottom temperatures show opposite trends: The waters are coldest during late spring and summer, and relatively slight warming periods occur in the winter months.

- Seasonal temperature changes in bottom waters are greatest at shallow (20 m) depths, where the average difference between the maximum and minimum measurements during a given year is about 3°C and the maximum variation during a year is 9°C. In deeper bottom waters (140 m) the mean temperature change is less than 2°C and the largest overall variation 3.5°C.

- In winter there is a much smaller overall temperature (and thus density) difference between surface and bottom waters than during summer and fall months. (Ref. 518.)

In summary, when coupled with currents, variation in temperature represents the single most important factor affecting the distribution of marine life and the vertical distribution of pollutants. The strong thermocline which persists over most of the year effectively prevents the intrusion of sewage/seawater plumes into surface waters. During winter, however, in the absence of distinct temperature discontinuities, such plumes are permitted to surface and may approach shore under the right wind conditions. (Ref. 504.)

Dissolved Oxygen

The majority of marine organisms which inhabit the southern California shelf region depend upon dissolved oxygen for their well being. Increasing numbers of organisms are excluded from a region as ambient dissolved oxygen levels are reduced. Very few types of organisms (notably anaerobic bacteria) have been observed to thrive under anoxic conditions. The stable chemical form or oxidation state of many substances changes as a result of dissolved oxygen depletion. The solubility and/or toxicity of these substances is often a function of their oxidation state.

Except within the euphotic zone where atmospheric exchange takes place, marine dissolved oxygen concentrations are normally considerably below saturation levels. Nevertheless, oxygen is normally abundant among marine waters and cases of low dissolved oxygen within the water column of the continental shelf are rare. Oxygen depletion can, however, provide local problems among marine sediments. Marine disposal of organic particulates, especially sludges, can generate or aggravate such problems. Furthermore, ambient dissolved oxygen concentrations in waters of the offshore basins are considerably lower than shelf waters, and basin sediments are periodically anoxic under natural conditions. The situation is particularly critical in the Santa Monica-San Pedro Basin, where dissolved oxygen concentrations below sill depths are on the order of 0.3 to 0.4 mg/l. (Ref. 501.) Figure 2 depicts typical dissolved oxygen profiles in local basin waters. (Ref. 507.)

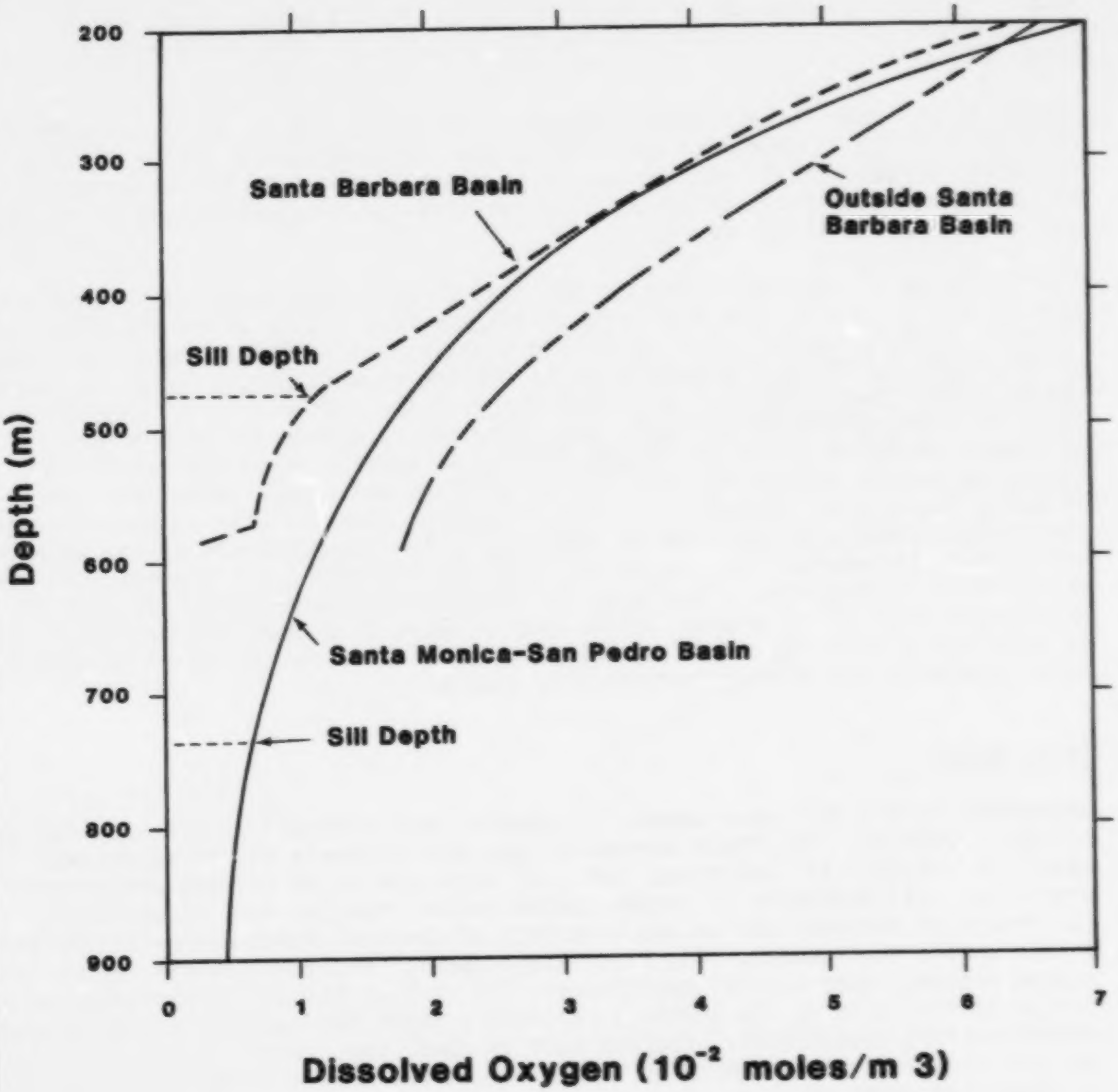
Oxygen is utilized in respiration by marine organisms and in the decomposition of organic matter. Upwelling may lead to the introduction of relatively low dissolved oxygen waters into the continental shelf area. On the other hand, photosynthetic activity and oxygen transfer from the atmosphere tend to increase ambient dissolved oxygen levels.

The discharge of treated wastewater can lead to dissolved oxygen depletion via several means. First, the discharge itself may have little or no dissolved oxygen content; second, the influx of dissolved organics may stimulate respiration among marine bacteria; third, decomposition of settled organic particulates may deplete oxygen levels among sediment pore waters and at the sediment-water interface; and, finally, although sewage nutrients may stimulate phytoplankton growth with attendant increased dissolved oxygen levels, decomposition of phytoplankton following intense blooms may lead to severe dissolved oxygen depletion. (Ref. 502.) It seems likely that disposal of large volumes of sewage sludge in waters of the continental shelf will not lead to dangerously low oxygen levels in the water column but will degrade benthic animal life and possibly lead to anoxic sediment conditions or generation of hydrogen sulfide. On the other hand, disposal of oxidizable material at greater depths carries with it a much greater probability of injuriously reducing receiving water oxygen levels. As mentioned previously, basin sediments are already periodically anoxic.

Trace Metals

Background levels for trace metals in seawater are difficult to estimate for the following reasons: (1) Their concentrations are extremely dilute in natural waters in relation to recognized limits of detection using current analytical practices. (2) Avoidance of sample contamination requires meticulous care. (3) Metals of interest can assume a variety of chemical forms and oxidation states in the marine environment. (4) Significant spatial variation exists in metals concentrations under natural conditions. (5) It is difficult to designate an appropriate control site in the Southern California Bight for purposes of background concentrations measurement. Factors such as upwelling, storm runoff, heavy rains, and the strength and proximity of sewage discharges lead to significant variation in receiving water metal levels.

The severity of biological effects attributable to the presence of heavy metals in the local marine environment has not been established. It is fairly certain that existing marine sewage disposal practice in southern California does not result in water column metal concentrations in excess of California State Ocean Plan standards outside the zone of initial dilution of individual discharges. However, the affinity of many heavy metals for sludge solids, particularly under reducing conditions such as are found during anaerobic digestion, has led to the concentration of heavy metals among local sediments. Such local effects would



SOURCE:

Assessment of Alternative Strategies for Sludge Disposal into Deep Ocean Basins off Southern California, Jackson, George, et al, Environmental Quality Laboratory California Institute of Technology, September 1979.

OXYGEN PROFILES OF DEEP BASINS OFF SO. CALIFORNIA

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 2

undoubtedly accompany either the baseline sludge disposal alternative or ocean disposal alternative outlined elsewhere in this report, although implementation of Federal industrial waste pretreatment regulations may provide some environmental benefits by reducing probable inputs. Additional material relative to sediment metal concentrations surrounding existing sewage sludge disposal sites is presented in material which follows.

Chlorinated Hydrocarbons

Extensive surveys of DDT and PCBs in surface seawater indicate that the highest concentration of pp' DDE (6 parts per trillion) and the PCB Arochlor 1254 (2 parts per trillion) were found near the Palos Verdes outfall site. Although these values are about 100 times greater than estimated background levels, they are many times below the overall California State Ocean Plan limitation for total identifiable chlorinated hydrocarbons (TICH). Data are not available with which to characterize receiving water concentrations of other synthetic chlorinated hydrocarbons.

Like most heavy metals, DDT and PCB forms are generally associated with sludge solids. Consequently, local problems associated with sediment concentrations of these compounds could be protracted by marine sludge disposal alternatives. Additional information related to sediment concentrations of selected chlorinated hydrocarbons is presented subsequently. Prior to the initiation of source control measures which greatly reduced the mass emission rate of DDT at the Joint Water Pollution Control Plant (Ref. 506.) (LACSD coastal treatment works) the suspected effects of DDT on the marine biota were geographically widespread, although generally confined within the Southern California Bight, indicating that DDT is somewhat mobile in the marine environment as a result of physical processes, biological activity, or both. The avenues of transport of this contaminant are not completely understood.

Pathogens

Marine waters contain many naturally occurring bacteria. These bacteria are responsible for degradation of organic material and nutrient cycling in the sea and serve as a food source for plants and animals. (Ref. 504.) While it is difficult to generalize, coastal marine waters above the thermocline support on the order of 300 bacteria/ml. Midwater values of from 10 to 100 have been reported in natural waters. In the immediate vicinity of outfalls bacterial counts are in excess of 1000 bacteria/ml. (Ref. 526) The observed local enhancement may be due to the addition of bacteria of sewage origin or stimulation of natural populations by the addition of nutrients. Growth among natural marine bacteria which are pathogenic to fish (e.g. *Vibrio anguillarion*) or both fish and man (e.g. *Vibrio parahemolyticus*) is expected in the presence of sewage nutrients. (Ref. 523.)

Total and fecal coliforms are the best indicators of the presence of sewage-related pathogens. Coliform bacteria are generally absent, or present in low concentrations, among the surface waters distant from southern California sewage discharge sites. Their concentration normally increases with depth and outfall proximity. As noted previously, the degree of density stratification is the primary oceanographic factor affecting the rise of the sewage/seawater plume and associated pathogens. Periodically during the winter storm season there is free exchange between deep and surface water masses permitting bacteria of sewage origin to reach the surface. (Ref. 504.)

Survival rates of pathogenic bacteria and enteric virus in seawater are not firmly established. It is known that bacteria and virus are subjected to a number of antagonistic phenomena in seawater. Most coliform bacteria do not survive for more than two weeks and sunlight is known to accelerate bacteria mortality. In addition, the coliform mortality rate in seawater increases with increasing hydrostatic pressure and temperature. Other factors influencing coliform survival include the degree of predation, aftergrowth (following discharge), and the solids content of the sewage. Attempts to quantify these competing processes or find an overall rate equation representing bacterial dieoff have not produced a reliable, mathematical treatment. (Ref. 502.) Specific viruses seem to be considerably more persistent in seawater than coliforms. (Ref. 525, 561).

Local and State public health records show no incidence of reportable infectious diseases or epidemics resulting from exposure to ocean coastal waters or beaches over the last 10 years (Ref. 523).

Bacterial limitations imposed by the State of California are met with sufficient regularity in waters surrounding major southern California marine discharge sites for one to conclude that existing sewage treatment and disposal practices can virtually eliminate such violations without major process changes. The most frequent violations of coliform standards are related to State bacterial quality requirements in shellfishing areas off the Palos Verdes coast. (Ref. 519.)

Light Transmittance

Light is a major factor in the growth of phytoplankton and the growth and reproduction of attached marine plants. It also affects the daily vertical migration of zooplankton and benthic fishes. As a consequence, the transparency of the water, or the depth to which light will penetrate, is of concern in considering many biological processes. (Ref. 501.)

The mean visual transparency of the coastal waters for all seasons varies from less than 6 to more than 15 m, with the lowest values occurring close to shore. Great variations occur over the southern California shelf. (Ref. 501.)

Transparencies are usually lower during the spring than during the fall, especially off the alluvial land plains of Ventura, in Santa Monica Bay, and off the coast to the south of San Pedro. This difference is probably associated with increased runoff of freshwater and detritus from the land during the spring season. (Ref. 501.) Also, phytoplankton blooms typically develop during spring months.

The coast, as a whole, is nearly always marked by a band of low transparency water within a mile or so of the beach. Within that area, transparencies of less than 6 m are common opposite alluvial land plains, with transparencies between 6 and 12 m typical of rocky shores. (Ref. 501.)

Settleable and suspended solids discharged in wastewaters decrease the water transparency in the immediate vicinity of the outfall. The extent and magnitude of the decreased transparency depends on the type of wastewater treatment, volume discharged, depth of the outfall, strength and depth of the thermocline, and local currents. In addition, the rising wastewater plume may also resuspend fine bottom sediments. Direct effects that may result from increased turbidity include a decrease in depth of the euphotic zone (and thus the primary productivity of the area) and clogging of respiratory or filter mechanisms of organisms residing in or passing through the area. (Ref. 502.) Using sensitive equipment it is possible to trace the paths of local wastewater discharge plumes for distances up to 10 kilometers on the basis of relative light attenuations. (Ref. 504.)

Cycles in phytoplankton growth are a second major cause of transparency reductions. Measurements of light attenuation in marine waters often expose layers of concentrated plankton forms overlying one or more layers of particulate matter of sewage origin. (Ref. 504.)

Available evidence shows that sewage-related nutrient enhancement may have stimulated phytoplankton growth in the vicinity of municipal outfalls within the Southern California Bight. (Ref. 506.)

SEDIMENT CHARACTERISTICS

Marine sediments provide clues regarding the source of materials contained therein, the physical transport processes affecting the distribution of material, and the chemical/biological characteristics of the benthic environment. Furthermore, the composition and health of benthic animals are logical indicators of sediment quality because of the typical lack of mobility of these creatures and the tendency of sewage-related contaminants to be concentrated in local sediments.

The ocean floor in the Southern California Bight is characterized by great areas of soft sediment with rocky areas of lesser magnitude intermixed. (Ref. 501.) There are also significant differences between sediments of the mainland shelf and those of the deep basins, two general areas which have been considered as potential sites for marine disposal of sewage sludge. As a consequence, those areas are considered separately in a discussion of physical, chemical, and biological sediment characteristics which follows.

Mainland Shelf

Most mainland shelf sediments are sand or sand-silt combinations. Geologically recent detrital sediments cover the majority of the shelf. Such sediments are low in calcium carbonate and consist principally of material derived from adjacent beaches on the shoreline. Mineral composition of the detrital sediments is similar to the sands of nearby beaches. (Ref. 501.)

Movement of material occurs in processes characterized by times from tidal periods to thousands of years. Turbulence and longshore transport, results of wave activity, can move sediments into large submarine canyons (e.g. Redondo Canyon) where they are lost permanently from the shelf. Thus, the overall process of sediment transport generally includes deposition of eroded material from land; longshore transport, primarily during periods of intense wave activity; and, ultimately, loss of sediments into submarine canyons. (Ref. 501.)

Submarine canyons occupy less than 1 percent of the sea floor in the Bight, but are important sediment pathways from the mainland shelf to the deep ocean basins. Erosion is the dominant transport process from the canyon heads to the points at which they open onto the deep basin floors. Canyons are also important as sites of local upwelling, serve as avenues for the migration of fish and invertebrates, and strongly influence wave refraction. (Ref. 501.)

In 1977, a survey covering 60-meter benthic stations located at 10-kilometer intervals between Point Conception and the United States/Mexican border was conducted by the Southern California Coastal Water Research Project (SCCWRP). The principal objective of the survey was to define the limits to what can be considered natural or background sediment chemistry and biological characteristics at that depth. Significantly, sixty meters is the average depth of discharge of the major sewage outfalls (except the Hyperion 7-mile sludge outfall which is at a depth of about 100 meters) in the Southern California Bight. The study, known as the "60-Meter Survey" provides data on outfall, and in some cases sludge-related benthic effects in relation to the observed range of background conditions. (Ref. 532.)

Sediment samples from all stations, including those most remote from human activities, contained measurable quantities of biochemical oxygen demand (BOD), chemical oxygen demand (COD), volatile solids, Kjeldahl nitrogen, hexane extractable materials (HEM), all seven trace metals analyzed, and chlorinated hydrocarbons. In addition to fairly broad ranges of control values, some obvious alterations in sediment chemistry were apparent in relation to urban areas, sewage discharges, and natural oil seeps. Benthic chemical data are summarized in Table 6 in a manner which emphasizes the range of control values in relation to extreme values from affected regions. Control values shown are considered representative at depths between 20 and 200 meters. (Ref. 532.)

The 60-Meter Survey is the most extensive synoptic study of shelf sediments yet attempted in the Southern California Bight. In material provided below, survey results, specific to selected chemical parameters, are augmented with the results of more localized monitoring efforts.

Organic Material

BOD, COD, volatile solids, and total organic carbon are measures of sediment organic content. Relevant data collected as part of the 60-Meter Survey are summarized in Table 6. Total organic carbon was not among the measurements undertaken in that study.

On the mainland shelf, total organic carbon generally comprises 0.5 to 1.0 percent of the sediment dry weight. By way of contrast, total organic carbon concentration increases steadily from about 1 percent to 4 percent in the first four kilometers offshore from the Palos Verdes Peninsula. With the exception of Palos Verdes sediment data which dates to the beginning of the 1970's, it is difficult to find a study of sufficient detail to permit development of geographical patterns in relation to an outfall site. (Ref. 504.)

TABLE 6

SEDIMENT CHEMICAL CHARACTERISTICS FROM THE 60-METER SURVEY 1977

	CONTROL VALUES			RANGE OF VALUES	
	Mean	95% CL(a)	No. of Stations	Control Stations	All Stations
Sand (%)	40.01	31.8-48.3	28	7.6-83.7	5.2-90.0
Volatile solids (%)	2.8				
Other Chemical Characteristics (mg/dry kg)					
BOD	632	554-709	28	266-1,017	172-25,048
COD	20,160	9,200-38,400	28	17,780-25,600	9,200-372,600
Organic (K) nitrogen	671	575-768	16	392-926	295-8,140
HEM	243	95-279	28	0-1,150	0-39,400
Total DDT	0.02	0-0.04	12	0.001-0.09	0.001-175.2
Total PCB	0.01	0.002-0.02	12	0.002-0.04	0.002-10.9
Silver	0.38	0.2-0.5	28	0.06-1.7	0.04-18
Cadmium	0.39	0.0-0.5	28	0.1-1.4	0.1-61
Chromium	23.1	19.8-26.4	28	6.5-43	6.5-1,317
Copper	9.1	6.9-11.2	28	2.8-31	2.3-782
Nickel	12.2	8.6-15.9	28	1.6-35	1.6-107
Lead	6.6	5.7-7.6	28	2.7-12	1.8-537
Zinc	42.2	37.1-47.1	28	9.8-62	9.8-2,096

Source: Southern California Coastal Water Research Annual Report, (1978).

(a) 95 percent confidence limits.

The deposition of organically enriched solids in the vicinity of major ocean outfalls seems related to the solids content of those discharges. Although the vast majority of discharged solids do not settle in the outfall vicinity (within, say, 10 kilometers), the local flux of sewage solids to the bottom is enhanced significantly by the presence of an ocean outfall. The pattern of deposition of sewage solids generally follows that of local currents. As a result, areas of elevated flux (and higher than background concentrations of sewage-related contaminants) are generally elongated in the longshore direction. It is significant that sediments surrounding the Hyperion 5-mile and Orange County Sanitation Districts outfalls, where discharges of solids are relatively low, exhibit little accumulation of organic material. On the other hand, heavy organic loads have accumulated in sediments proximate to the Los Angeles County and the Hyperion 7-mile (sludge) outfalls. Volatile solids concentrations in Palos Verdes shelf sediments range from 5 to 27 percent (dry weight). Around the Hyperion 7-mile outfall, volatile solids range from 2 to 30 percent and values of 10 to 20 percent are typical down the Santa Monica Canyon from the outfall. (Ref. 504.) Comparison of these values to the mean background volatile solids concentration from SCCWRP's 60-Meter Survey reveals the magnitude of organic enrichment among local sediments. The biological significance of such enrichment will be explored in a later section of this report.

Trace Metals

Because heavy metals in sewage and sewage sludges are primarily associated with the particulate phase, the enhancement of heavy metals in mainland shelf sediments roughly parallels the pattern observed in sediment organic content.

Background trace metal sediment concentrations developed in the 60-Meter Survey are provided in Table 6, and Table 7 is a summary of surface sediment metals data representing the vicinities of the LA/OMA discharge sites (exclusive of the Hyperion 5-mile outfall). Sediment enrichment is indicated for some trace metals.

The question of trace metals mobilization has been approached theoretically, on the basis of equilibrium considerations, and empirically. Under reduced conditions such as would characterize primary effluent or anaerobically digested sludge, thermodynamic considerations indicate that most trace metals are very insoluble. However, under oxidizing conditions present following initial dilution of sewage or sludge with seawater, differing degrees of solubilization of trace metals would be expected. Equilibrium theory indicates that nickel is solubilized in the water column to the greatest degree. Following deposition of sewage particulates among local sediments the redox character of the sediments (reduced or oxidized) would play a role in metal mobilization and speciation. (Ref. 560.)

A number of sources of empirial evidence suggests that if metals mobilization from the sediments does occur, it is a slow process. Recent publications suggest that (1) under aerobic conditions, cadmium, copper, nickel, lead, and zinc tend to be mobilized from contaminated sediments; (2) under anaerobic conditions, iron and manganese are mobilized; and (3) mercury and chromium remain insoluble under either condition. However, very different degrees of mobilization were observed

TABLE 7

IN SEDIMENTS AROUND LA/OMA MUNICIPAL OUTFALLS

(milligrams per dry kilogram)

	Orange County (a)		Los Angeles County (b)		City of Los Angeles 7-Mile Outfall (c)	
	Max	Aug	Max	Aug	Max	Aug
Silver	1.0	0.6	---	---	41.8	8.8
Cadmium	3.4	1.7	60.8	32.5	65	21.3
Chromium	63	43	1317	1098	864	216
Copper	59	39	782	479	1010	302
Nickel	18	13	107	61	231	63.8
Lead	29	21	537	298	597	136
Zinc	82	60	2096	1188	---	---
Mercury	---	---	---	---	6.1	1.7

(a) Data are from "Southern California Coastal Water Research Project, "Report on Task 2, Describe Existing Conditions", Task Report to LA/OMA Project, (September 29, 1977). Average is for the six closest stations to the end of the outfall as reported in third quarter of 1977 monitoring data.

(b) Data are from "Joint Water Pollution Control Plant Application for Modification of Secondary Treatment Requirements for Publically Owned Treatment Works Which Discharge into Marine Waters", Los Angeles County Sanitation Districts, (September 13, 1979). Data are for surface sediment concentrations as reported in Table XI-B-28 of the Waiver Application.

(c) Data are from "Sludge in Santa Monica Bay", Schafer, Henry A. and Bascom, Willard, Southern California Coastal Water Research Project Annual Report, (1976). Values shown are from 26 stations.

when Los Angeles County Sanitation Districts' sludges were mixed with seawater than when similar experiments were run on City of Los Angeles sludges. (Ref. 504.)

Chlorinated Hydrocarbons

Data from control stations indicate that background concentrations of Total DDT and Total PCB in surficial sediments are on the order of 0.02 mg/dry kg and 0.01 mg/dry kg respectively (see Table 6). Higher concentrations are found in sediments near outfalls.

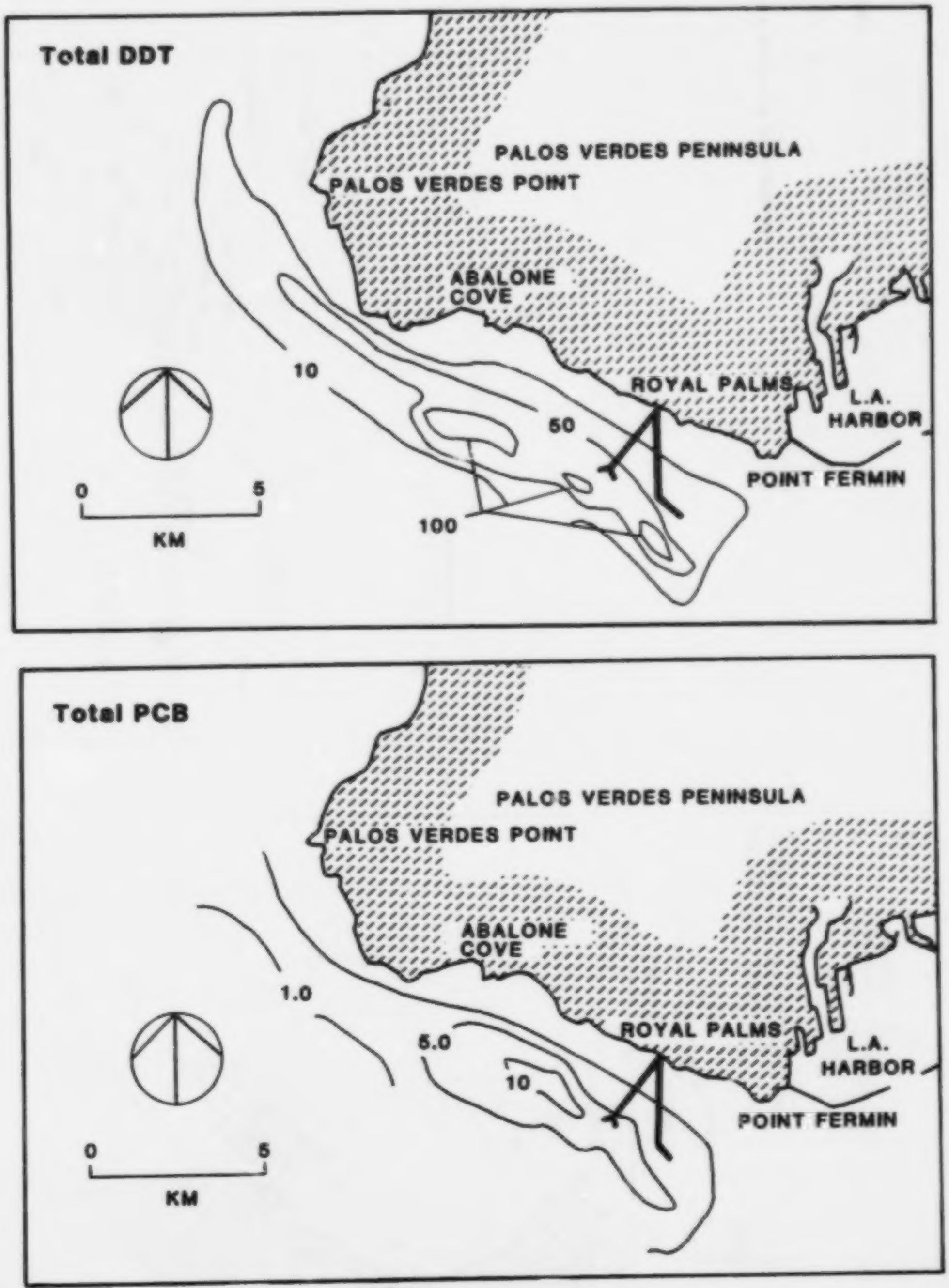
The discharge of DDT into waters of the Southern California Bight represents a unique water pollution control problem in that, historically, the majority of the area-wide input was from a single source, the Los Angeles County Sanitation Districts' outfall system. As a result, some dangerously high concentrations of total DDT have accumulated in the Palos Verdes sediments. In the years immediatly prior to 1971 an estimated 500 lbs/day (over 90 tons per year) of DDT were discharged via the Districts' outfalls. Although source control measures begun in 1970 have reduced the mass emission rate of DDT from the Joint Water Pollution Control Plant (JWPCP) by more than two orders of magnitude, a great volume of this persistent and potentially dangerous chemical is still present in the Palos Verdes sediments. Because more recent discharges from JWPCP and the associated flux of material to the Palos Verdes sediments have contained relatively little DDT, its concentration has decreased in local surface sediments in recent years with a concommitant decrease in body burdens of creatures exposed to this material. Ironically, the decrease in mass emission rate of solids from JWPCP which is predicted to accompany implementation of secondary treatment and solids handling improvements could result in the reemergence of previously buried sediments bearing high levels of DDT. The highest levels of DDT observed in sediments off the Palos Verdes Peninsula were over 200 mg/dry kg in 1971. DDT mass emission rates and sediment loads at each of the other LA/OMA discharge sites are substantially lower than those associated with the Palos Verdes discharge (Ref. 519.)

PCB concentrations in surface sediments are high relative to other discharge sites in the area of both the Palos Verdes and Hyperion 7-mile outfalls. It seems likely that PCB's are also associated with sewage particulates. The highest levels of PCB observed in these areas are on the order of 4 mg/dry kg. Concentrations in the vicinity of the Orange County outfall are below 0.1 mg/dry kg. (Ref. 519.)

Figures 3, 4, and 5 provide a general picture of the distribution of DDT and PCB in surface sediments surrounding the Hyperion 7-mile, Palos Verdes, and Orange County outfalls. Figure 6 illustrates the variation of DDT concentration with depth which is typical of Palos Verdes sediments in the vicinity of the Los Angeles County Sanitation Districts' outfall system. Causes of the observed variation are explained above.

Pathogens

Sediments generally contain one or two orders of magnitude more bacteria per unit volume than does the water column above it. Furthermore, because viruses are readily adsorbed on suspended particulates (and their association enhances survival)



KEY

Values are in mg/dry kg as measured in the top 5 cm. in 1975.

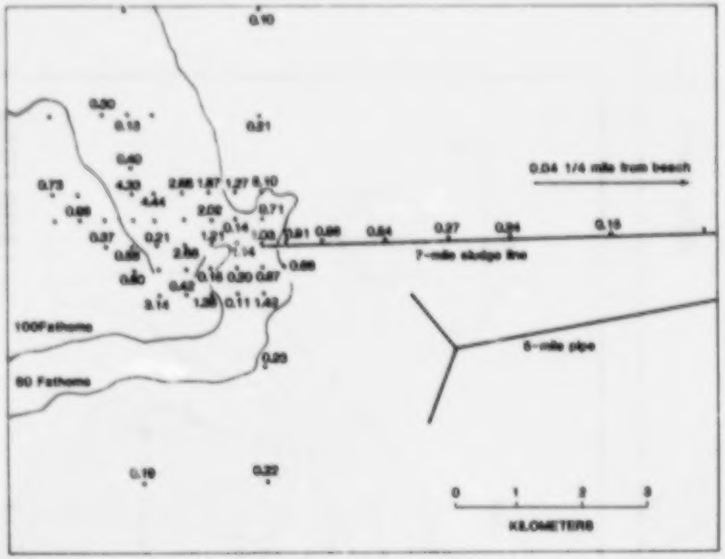
SOURCE:

"Report on Task II, Describe Existing Conditions", Task Report to LA/OMA Project, Southern California Coastal Water Research Project, (September 29, 1977).

SEDIMENT NEAR
L.A. COUNTY OUTFALLS

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

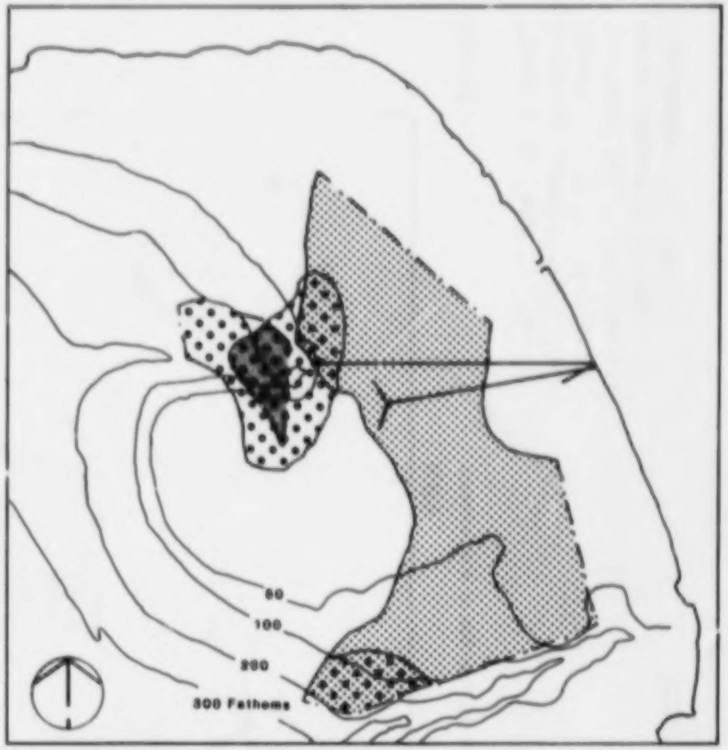
FIG. 3



DDT AND PCB IN SEDIMENT

NOTE: Data are from SCCWRP unpublished data, 1976.

SOURCE: "Report on Task II, Describe Existing Conditions", Task Report to LA/OMA Project, Southern California Coastal Water Research Project, (September 29, 1977).



KEY

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▨ Total DDT > 0.12 ppm Phleger Cores July 72

■ Total DDT > 2 ppm Box Cores July 71

⁘ Total Chlorinated Hydrocarbons > 440 ppm

DDT AND CHLORINATED HYDROCARBONS IN SEDIMENT

SOURCE: Draft Environmental Impact Statement, City of Los Angeles Wastewater FAcilities Plan, (September, 1977).

TRACE ORGANICS IN SEDIMENTS NEAR L.A. CITY OUTFALLS

FIG. 4

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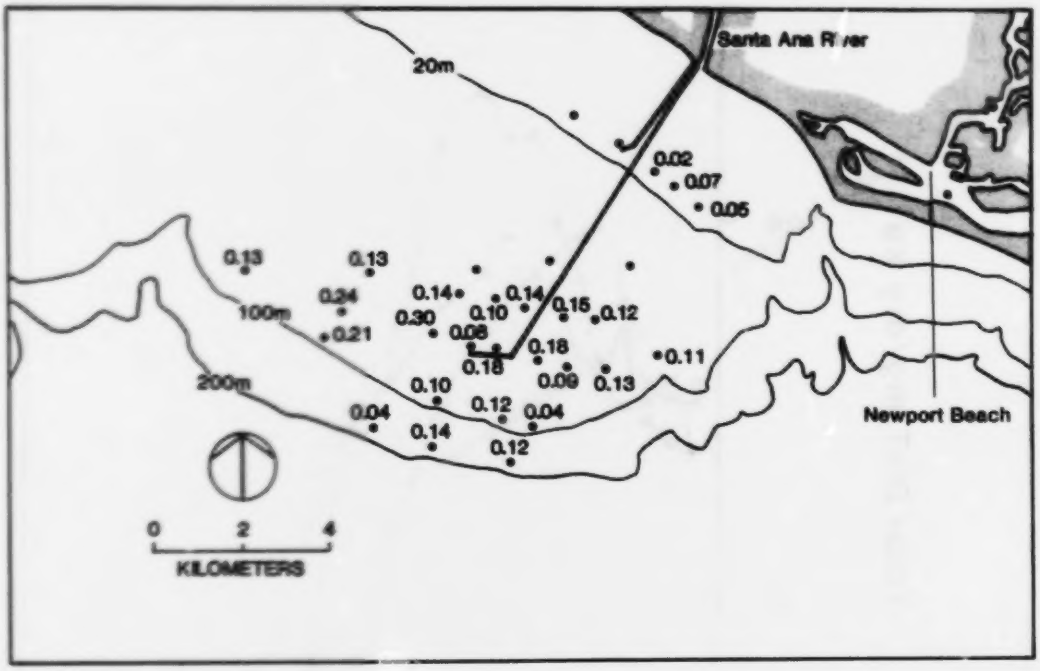

NOTE: Values are in mg/dry Kg as measured in the top 2 cm in July 1975.

DDT values are less than 0.01 mg/dry Kg.

SOURCE:

"Report on Task II, Describe Existing Conditions", Task Report to LA/OMA Project, Southern California Coastal Water Research Project, September 29, 1977.

PCB IN SEDIMENT NEAR ORANGE COUNTY OUTFALLS

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 5

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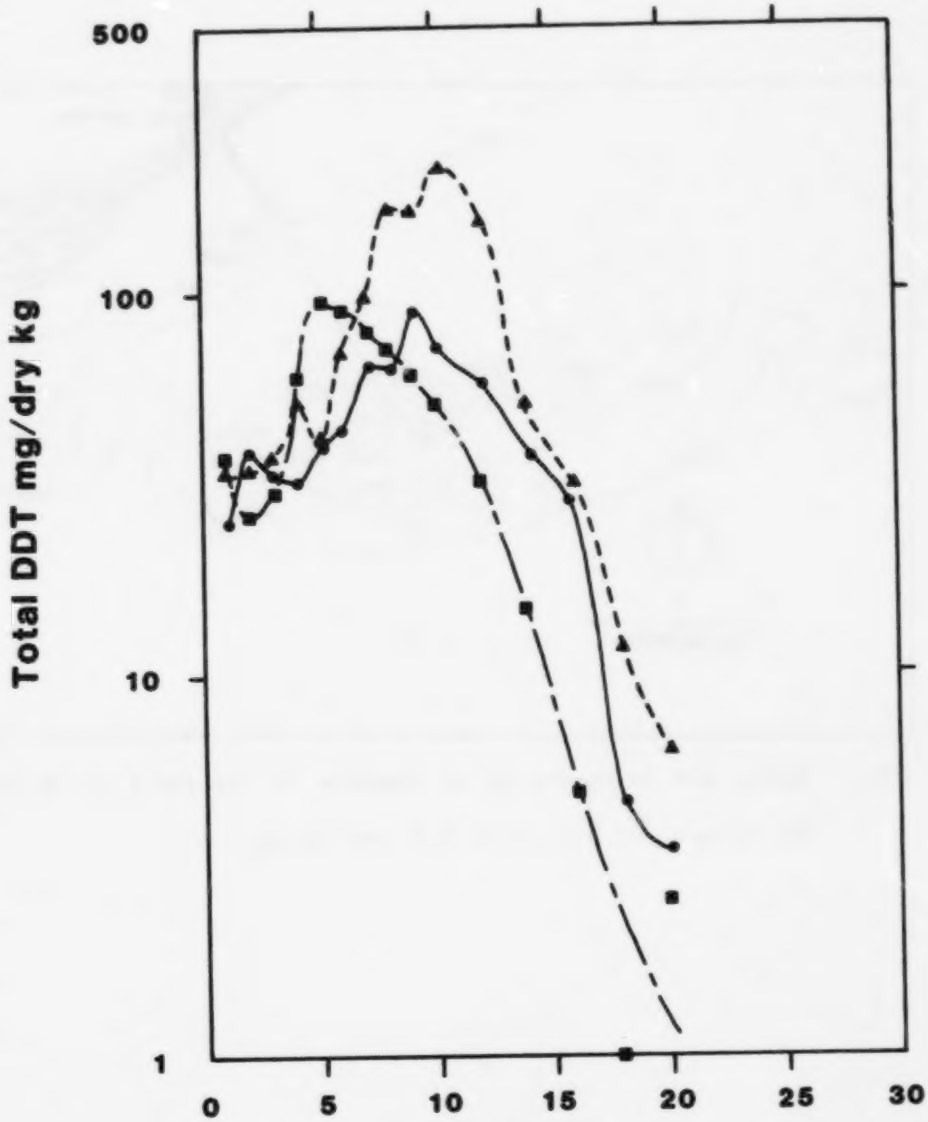


Sediment Depth cm

SOURCE:

Los Angeles County Sanitation Districts, "Joint Water Pollution Control Plant Application for Modification of Secondary Treatment Requirements for Publicly Owned Treatment Works Which Discharge into Marine Waters", September 13, 1979.

NOTE: Data shown are for October 1976.

SEDIMENT DEPTH PROFILE-DDT CONCENTRATIONS PALOS VERDES SHELF

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 6

it is likely that viruses accumulate in the sediments as well. (Ref. 502.) Furthermore, it seems probable that the discharge of sludges to the mainland shelf would lead to the further elevation of bacterial and viral pathogens in mainland shelf sediments.

Deep Basins

The bulk of the sediments deposited on the continental borderland have been transported to the Bight from adjacent land areas. Deposition is accomplished by three modes: detrital sediments diffused from the mainland by volume suspension in runoff and air, chemical and organic sedimentation from the water column, and turbidity currents from near the mainland. All three modes are important in nearshore basins where the chief mode of deposition is turbidity currents from submarine canyons and slopes. (Ref. 501.) (Ref. 520.)

Sediment inputs to Santa Barbara and Santa Monica-San Pedro Basins are listed in Table 8. Note that almost all sedimentation processes occur faster in Santa Barbara Basin when rates are normalized with respect to area.

Organic Matter

Measurements of deep basin organic carbon content indicate accelerated deposition of organic material in these areas. In the middle of the Santa Monica Basin, total organic carbon sediment concentrations are between 4 and 7 percent of dry sediment weight. (Ref. 504.) In all cases, generalizations relative to deep basin characteristics are based upon much less data than are similar observations related to mainland shelf sediments.

Trace Metals

Sediment core data indicate that lead, chromium, zinc, copper, silver, vanadium, molybdenum, and probably other metals are accumulating in the Santa Monica-San Pedro Basin at higher rates than, say, a century ago. (Ref. 521, 558.) Nevertheless, in the absence of a major, direct input of sludge, fluxes of trace metals to the Basin floor are considerably lower than rates of accumulation observed on the mainland shelf.

Chlorinated Hydrocarbons

Data on chlorinated hydrocarbons derived from examination of dated varved samples from Santa Barbara Basin are shown in Figure 7. These data suggest that deposition of measurable PCB began in 1945 and that DDT compounds first appeared in sediments in about 1952. It appears that the majority of DDT compounds entering the Santa Barbara Basin in 1967 came from local sources. It has been hypothesized that a sub-thermocline current moving northward from the Los Angeles Basin and through the Channel Islands at a depth of about 200 meters might be a source of DDT and PCB compounds in sediments of the Santa Barbara Basin. (Ref. 522.)

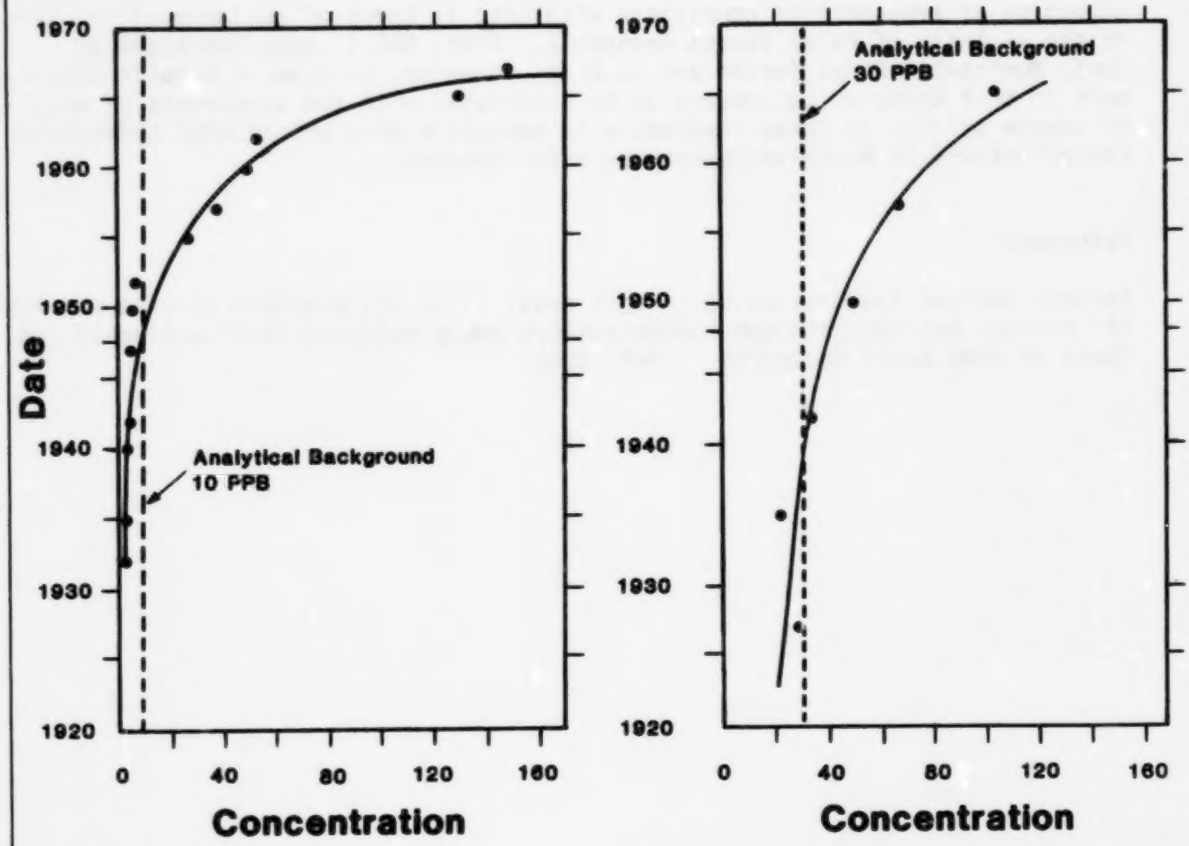
TABLE 8

SEDIMENTARY INPUTS TO LOWER BASINS

(Values from Bruland, et al. (1974) and Hulsemann and Emery (1961)

	Santa Barbara Basin			Santa Monica-San Pedro Basin		
	Rates or Fluxes			Rates or Fluxes		
	Natural	Anthropogenic	TOTAL Tons/year	Natural	Anthropogenic	TOTAL Tons/year
Sedimentation Rate						
mm/yr	4.			0.8	-	
gm-solids/(m^2-yr^{-1})	900.		600,000	260.	-	640,000
Fluxes						
Organic carbon gm $m^{-2}yr^{-1}$	45.		30,000	13.		31,000
Organic nitrogen gm $m^{-2}yr^{-1}$	3.		2,000	0.4		1,000
Heavy metals mg $m^{-2}yr^{-1}$						
Pb	10.	21.	20	2.5	12	36
Cr	107.	29.	90	25.	28	130
Zn	97.	22.	80	30.0	20	123
Cu	26.	14.	26	11.	12	56
Ag	1.1	1.0	1.4	0.4	0.9	3.2
V	135.	78.	141	35.	20	135
Cd	1.4	0.7	1.4			
Mo			-	0.8	8	22
Ni	41.		27	15.		37
Co	10.		6.6	3.0		7
Mn	100.		66	240.		590
Fe	12,000.		7,900	30,000.		74,000
Al	17,000		11,000	50,000.		120,000

Source: Draft Final Report, Assessment of Alternative Ocean Sludge Disposal Practices, Jackson, George, et.al., Environmental Quality Laboratory, California Institute of Technology, December 1978.



SOURCE:

Southern California Coastal Water Research Project Annual Report, (1974).

DDT AND PCB IN SANTA BARBARA BASIN SEDIMENTS

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 7

The hypothesis is based upon data from a 1971 survey of synthetic organics in intertidal mussels (Mytilus californianus). The highest values of DDT and PCB in mussels taken from island waters were found at Santa Barbara Island. This direction of transport is consistent with what is known of subthermocline currents in the vicinity of Palos Verdes Peninsula. (Ref. 504.) Data representing Santa Monica-San Pedro Basins are lacking. However, in view of organic enhancement in that area, which appears to be associated with the appearance of material of sewage origin, it seems reasonable to speculate that chlorinated hydrocarbon concentrations in Basin sediments are also elevated.

Pathogens

Perhaps because few data exist in this area, it is not possible to cite meaningful differences between pathogen concentrations among mainland shelf sediments and those of deep basin sediments. (Ref. 526).

MARINE BIOTIC SETTINGS

CLASSIFICATION OF THE MARINE ENVIRONMENT ●
SPECIES COMPOSITION ●
SENSITIVE SPECIES AND AREAS ●
FOOD WEB ●

Detailed knowledge of the marine biota, particularly those organisms inhabiting the water column and deep basins, is limited due to difficulties of access and the complexity of the ecosystem of the Southern California Bight and resulting expense associated with conducting the required studies. Only a few chemical constituents have been extensively studied -- principally because of interest associated with disposal of wastes in the marine environment. However, while complete knowledge is lacking, data are available to expose some of the consequences of waste disposal in the marine environment. Such data have resulted from field measurements and laboratory studies directly concerned with the Southern California Bight and with studies from other areas. Given the complexity of the local marine ecosystem and the nature of the environmental concerns, continuing study to obtain a better understanding is an expected and necessary adjunct to implementation of any project alternative which considers sludge discharge to the marine environment.

CLASSIFICATION OF THE MARINE ENVIRONMENT

In order to facilitate study of the environment and its inhabitants, the marine environment may be classified into broadly defined biotic divisions. Boundaries between these divisions are in some instances well defined but more frequently there is a good deal of overlap. (Ref. 528.)

The three primary divisions of the marine environment are the air/water interface, pelagic (water column), and benthic (ocean bottom). Each of these broadly defined habitats support a unique assemblage of organisms. The abundance, diversity, and productivity of the marine life within each habitat is governed by the combination of light, temperature, oxygen, nutrient availability and substrate type existing in two major physiographic regions -- Nearshore and Offshore. Light plays an essential role in the marine ecosystem. In the euphotic zone (the uppermost part of the water column), energy and inorganic chemicals are converted into organic matter through photosynthesis. It is through this process that principal primary production of food for marine life occurs. (Ref. 523.) Temperature, oxygen, and nutrient availability are generally closer to optimal in the upper water column and decrease (except nutrients) with depth.

Nearshore Region

The nearshore region extends from the shoreline to the edge of the inner coastal shelf at a depth of 100 meters. Shoreline habitats for marine and shore birds as well as habitats in the overlying water and sediments of the coastal shelf are included within this region.

The intertidal area, where natural stress conditions exist due to wave shock and periodic tide-induced dessication, extends from the highest wave washed level to the lowest tidal water level. The subtidal area, an area of continuous submergence, extends outward from the lowest tidal level. (Ref. 524.)

The majority (80 percent) of the mainland shores of Southern California coast consist of sandy beaches. The shoreline of Santa Monica Bay and Orange County, from Seal Beach to Newport Beach, consists almost exclusively of sandy beaches with some piers and jetties. Rocky intertidal areas are located along Palos Verdes Peninsula, at rock jetties extending seaward at the entrance of Ballona Creek near Venice, and south of Newport Beach to Dana Point. (Ref. 502.)

In the subtidal area, most sediments are soft, composed of sand-silt combinations, and diminish in grain size with distance offshore (Ref. 501, 504). Exceptions to this are rock and gravel occurring close to shore in an elongated tract from Point Dume to Malibu, at shallow depths of the Palos Verdes Peninsula, and in scattered locations across the central part of the coastal shelf (Ref. 502). On a gross scale rocky substrate exist generally to the 10 meter depth at Palos Verdes, but in some instances it extends to the 30 meter depth contour. Offshore of this area soft substrate is found. Soft substrate composed of sedimentary material also occurs in Santa Monica Bay and offshore of Orange County. (Ref. 524.)

Offshore Region

The offshore region extends seaward from the nearshore region and includes waters of great depth. In Southern California, these waters are in close proximity to the coast as a result of deep basins and the submarine canyons which traverse the coastal nearshore region. Further offshore of the Southern California borderland, the coastal shelf break at 1000 m marks the westerly extension of the continental shelf and the beginning of the deep (>4000 m) Pacific basin.

In the offshore region, the water column consists of the epipelagic (water surface to about 200 meters), mesopelagic (from about 200 meters to about 700 meters), and bathypelagic (greater than about 700 meters) zones (Ref. 530). In the open ocean a fourth zone, abyssalpelagic (greater than about 4,000 meters) is found. Within the epipelagic region is the euphotic zone where net photosynthesis occurs. As depth increases, light and oxygen diminish in availability and in turn, biological diversity and abundance also decrease. (Ref. 529.)

The deep offshore benthic habitat is characterized by fine sands and muddy substrates with little or no light penetration (Ref. 524). Survey of the Santa Monica -San Pedro Basin has disclosed that the bottom of the basin is littered with natural debris (fish bones, scales, shells and tubes of invertebrates, undecomposed algae, brush and wood), human trash (beer cans, tin foil, paper, plastic), and material of undetermined origins (tar globs). This survey did not detect hydrogen sulfide odor in grab samples of sediments. (Ref. 530.) However, it has been reported that interstitial waters deeper than a few centimeters is devoid of oxygen and inhospitable for most animals (Ref. 507).

Man-made Structures

Offshore oil platforms and ocean outfalls attract a variety of marine organisms and function as artificial reefs, although not intended for such purposes. Many of these structures have been placed on soft substrate bottoms and provide organisms with hard substrate for attachment in areas where such habitats are reduced or nonexistent. Oil platforms provide more complex habitats than do outfall pipes because the platforms extend to the surface giving both vertical relief and shady "canopy" similar to that of kelp beds. (Ref. 531.)

SPECIES COMPOSITION

Coastal waters off Southern California harbor an abundant and extremely variable flora and fauna. There are at least 160 kinds of phytoplankton; over 700 kinds of planktonic invertebrates and larval stages of fishes; large, highly migratory stocks of pelagic fishes; and numerous populations of pelagic birds and mammals. (Ref. 504.) Abundance within and between populations changes from year to year and from locality to locality. In an area of the size and complexity of the Bight, it is seldom possible to find organisms which are abundant at all localities during all seasons. (Ref. 524.)

The variety of forms of marine life in a coastal area is primarily dependent on the stability and variety of food organisms and habitats. Where one type of food is abundant, the diversity is low but a few kinds of fishes and invertebrates will be present in great abundance. However, where a variety of habitats and food exists, diversity is generally high but abundance may be reduced. (Ref. 523.)

Water Column

The pelagic regime, including conditions, currents, transport, chemistry, and organisms, is most directly affected by large scale variations in weather and oceanographic conditions resulting from the intermixing of waters in the Southern California Bight. This variable environment is favorable to opportunistic organisms and populations that are stress-tolerant and adaptive. (Ref. 506.)

In the other environments of the Bight -- those of the littoral, bathypelagic, and benthic creatures -- the intensity of these fluctuations is modified. In these environments, some real degree of stable, balanced ecological complexity may often exist (Ref. 562). However, the substantial, decade-to-decade natural fluctuations observed among littoral and shallow benthic species and populations indicate that the ecological balance of these regimes is also profoundly affected by large-scale fluctuations, although on a longer time scale.

With some notable exceptions, the local biota of the water column is not sampled regularly, and it is not possible to compile a complete picture of the marine life in the local pelagic ecosystem. However, general trends which are apparent include:

- Pelagic marine life (including fishes and plankton) are more concentrated near the surface than in mid-water depths.
- Plankton are more concentrated in nearshore waters than offshore.
- Both pelagic fish and plankton communities are unevenly distributed along the coast but occur in large, scattered patches and schools, some of which may congregate near municipal discharge sites for prolonged periods of time. (Ref. 504.)

Significantly greater species diversity and abundance have been in evidence in waters above the nearshore coastal shelf than in the deep basins beyond and below the shelf (300+ meters depth), presumably due to differences in nutrients and dissolved oxygen concentrations. (Ref. 507.)

Phytoplankton

Planktonic organisms in the water column include phytoplankton and zooplankton (both small invertebrates and larval stages of marine species). Phytoplankton are single-celled aquatic plants which drift with the currents and which are able to utilize dissolved nutrients in remarkably low concentrations. All animals in the ocean ultimately owe their existence to the photosynthetic producton of organic matter by phytoplankton in the euphotic zone. (Ref. 523).

Variations in nutrient availabiity and accessibility, especially nitrogen, is an important force in changing primary production. Local surface waters are generally poor in nutrient content until the onset of seasonal upwelling. This dramatically increases nutrient content of local surface waters. There is a 20-fold variation in primary production rates other than at the major outfall locations. Primary production is generally highest in summer. (Ref. 504.)

The phytoplankton community are the primary producers which form the base of the aquatic food web. The most important groups of algae which comprise the bulk of phytoplankton off the Southern California coast are: the diatoms (Bacillariophyceae); dinoflagellates (Dinophyceae); small flagellates or "monads" belonging to the Crytophyceae; and, to a lesser extent, coccolithophorids (Haptophyceae). Each of these algal groups tends to predominate during particular seasons characterized by specific environmental conditions. The mechanisms of phytoplankton succession are not entirely understood, but they seem to be related to seasonal changes in light availability, nutrient input, turbulence and upwelling, and, in some cases, selective grazing by herbivores. (Ref. 506.)

In general, diatom blooms occur during the spring, the period of greatest upwelling. Dinoflagellates and "monads" are the greatest contributors to total biomass locally except after this spring upwelling. (Ref. 506.)

Dinoflagellate blooms off this coast, like diatom blooms, are associated with upwelling conditions. However, such blooms typically develop in calm, warm weather during periods of weak upwelling. In such periods upwelled nutrients do not reach the surface, due to the presence of a shallow, but steep thermocline. Such receiving water conditions generally occur in the summer and early fall. If the bloom becomes sufficiently dense with a particular species, a condition known as "red tide" results. Red tides are of particular environmental concern because the toxin from certain dinoflagellates (although not the Southern California species) can cause harvested shellfish to be poisonous. Furthermore, dense decaying blooms can result in oxygen depletion and fish kills. A red tide is a complex development which seems to be favored by low circulation, nutrient enrichment, warm temperatures, and the presence of a seed population of organisms, usually a dinoflagellate species. The Southern California dinoflagellate red tide species are fairly large and cannot utilize the very low nutrient levels available to smaller, faster growing cells. Many are capable of diurnal, vertical migration of 10 to 15 m. This faculty is advantageous during conditions of weaker upwelling, inasmuch as they probably can extract vital nutrients from subsurface water after residing in the well-illuminated, though nutrient poor, surface water during most of the day. Under more turbulent conditions, their motility no longer represents an advantage over non-motile phytoplankton, and other species with faster growth rates predominate. (Ref. 506.).

Zooplankton

Zooplankton are a heterogeneous group of small animals that fulfill several roles in the food web as herbivores, carnivores, and detritivores. Zooplankton are represented in many forms, a few of which include protozoa, arthropods (such as copepods and krill), certain groups of molluscs, and the eggs and larvae of many other marine groups. Basically, zooplankton consist of the passively floating or weakly swimming animals which are transported chiefly by the action of sea currents. (Ref. 505.)

Although phytoplankton are necessarily limited to the euphotic zone, zooplankton continue to be found, in gradually decreasing numbers but often increasing size, within the deeper waters. In addition there is a continual rain of dead and decaying zooplankton and other marine life which support a host of bottom dwellers. (Ref. 505.)

Most studies of zooplankton have emphasized distribution in the open ocean or in bays and little is known about the distribution and abundance of offshore (5 to 10 nautical miles from shore) zooplankton species along the California Coast. Species composition of zooplankton communities at the nearshore region differs from that in the ocean by having a higher proportion of larval organisms that may or may not be planktonic as adults (meroplankton) and by having higher densities of some true plankton (holoplankton), particulary copepods. The characteristic species of the coastal region generally have peak abundances 1.6

to 3.2 km from shore. Comprehensive data on zooplankton distribution and abundance are difficult to gather because of patchy distributions and vertical migration. (Ref. 502.)

The most abundant zooplankton are the crustaceans, which include copepods, cladocerans, amphipods, decapods, and euphausids. Amphipods are mostly benthic but a few pelagic taxa exist. Euphausids, shrimp-like crustaceans often known as krill, are part of the plankton community as larvae, but are too large and strong swimming to be considered planktonic in the adult stage. Separate taxonomic groups of the widely distributed euphausids are associated with various water depths. They feed mainly on phytoplankton and sometimes are abundant at sites of upwelling. (Ref. 502.)

In addition to crustaceans, the zooplankton community often includes primitive chordates, molluscs, chaetognaths, polychaetes, coelenterates, and ctenophores. The primative chordates (thaliaceans) that sometimes numerically dominate the zooplankton in the epipelagic zone include salps and doliolids, especially in the summer when water temperatures exceed 14-15°C. (Ref. 502.)

Four taxonomic groups, copepods, thaliaceans, euphausids, and chaetognaths, account for 75 percent of the overall biomass and dominate the offshore community. Copepods and thaliaceans are most important and are susceptible to major seasonal and long-term variations in standing crops. (Ref. 504.)

Larval stages of many organisms are planktonic, while adults are often either benthic or nektonic. Major contributions of the larval stage are (1) a stage of growth that leads to the adult; (2) a means of dispersal of the population; and (3) a mechanism of habitat selection for the adult. (Ref. 527.)

The first attribute is obviously vital to the life process of an organism. Ability for dispersal of young appears in great part to offset associated difficulties such as the high mortality rate of planktonic larvae. Although some larvae remain in the plankton only a few hours, most remain for several days to a few weeks or even months. Widespread distribution avoids competition between offspring and adults, promotes outbreeding among adults, and provides potential for populating new areas or repopulating old areas. (Ref. 527.) The third contribution is extremely important to sessile or weakly motile animals. When the planktonic larvae of such animals settle, they commit their adult stages to an existence at or near the point of settling. Therefore, it is a great advantage if such larvae can exercise some selectivity in settling and choose a habitat that is propitious for the oncoming adult stages. The larvae of the barnacle Balanus balanoides have adapted to select rock surfaces in shallow water suitable for adult habitation. If they do not find a suitable settling surface they may delay metamorphosis and continue to search for up to two weeks. Not all larvae exercise such extensive habitat selection, but a number of cases are now well known, and it is likely that the function is widespread. (Ref. 527.)

After hatching an anchovy fish larva requires 20 days growth in planktonic form to develop into a juvenile organism. Survival of the larvae during this period is on the order of 0.06 percent, and a slight deviation in the survival rate will greatly affect the size of subsequent year classes. Survival is highly dependent upon availability of phytoplankton (as food) shortly after hatching. There is strong evidence that larval requirements are met only when phytoplankton form dense (up to 35,000 cells per square meter) layers below the surface. When storms mix the layers, anchovy larval mortality is greatly increased. (Ref. 504.)

Pelagic Fish and Invertebrates

Many of the larger planktonic invertebrates have strong swimming abilities. Nektonic organisms, those which can maintain their position and move against local currents, include species of cephalopods, decapods, euphausids, mysids, and some other crustacean groups. Species of commercial or recreational value in Southern California are ocean shrimp (*Pandalus jordani*), bay shrimps (*Cragon spp.*), spot prawn (*Pandalus platyceros*), pelagic red crabs (*Pleuroncodes planipes*), and market squid (*Loligo opalescens*). (Ref. 502.)

Distribution of nektonic invertebrates varies seasonally and diurnally. Most species school and many migrate vertically on a daily cycle. Mysids especially vary their regimes: demersal or epibenthic part of the time, and nektonic most often at night. Red crabs occur in high concentrations near areas of upwelling. The market squid is most abundant in nearshore areas in the spring spawning period. The abundance of nektonic decapod crustaceans is low in the Southern California Bight. (Ref. 502.)

Of the 554 species of marine fish known to occur along the California coast, at least 481 species are found from Point Conception to the Mexican Border. The number of species and families increase from north to south along the California coast with 90 percent of the families occurring in southern California compared to 71 percent in northern California. (Ref. 502.)

Movements and migrations of fish, both with depth and location, are often complex. Factors known to affect these movements include light, temperature, currents, availability of food, and presence or absence of predators. Changes in these factors can be a function of natural periodic or aperiodic fluctuations as well as anthropogenic activities such as wastewater and thermal discharges and fishing pressure. Distribution of fish is also determined by the natural life cycles of the various species. Although the distribution and movements of commercially important fish are relatively well known, considerably less data are available on the fluctuations of neashore fish populations which may be more directly influenced by human activities. (Ref. 505.)

When upwelling occurs, many fish associated with the nearshore area avoid the intruding water mass by moving either inshore (demersal fish) or to the surface and offshore (pelagic fish) probably in response to differencies in water characteristics such as temperature and oxygen. Some fish species such as those of the distinct San Diegan fauna are found only in association with warmer waters that occur above the thermocline. Below the thermocline and in upwelled waters of the nearshore area, the fish are cool water species with distribution centers north of the Southern California Bight. (Ref. 502.)

Kelp beds, semi-enclosed bays, and man made structures (e.g., oil rigs, harbors, breakwaters, etc.) provide habitats for fish in the nearshore area. The offshore area is inhabited by pelagic fish while the nearshore area has primarily demersal (bottom dwelling) species (to be discussed in a later section) and a few pelagic species such as anchovies. (Ref. 502.)

Fishes dominate the community of predators that feed primarily upon each other and zooplankton. Important commercial species include Northern anchovy (Engraulis mordax), California barracuda (Sphyraena argentea), Pacific bonita (Sarda chilensis), Jack mackerel (Trachurus symmetricus), White sea bass (Seriola dorsalis), Pacific mackerel (Scomber japonicus), and Pacific sardine (Sardinops sagax caeruleus). With respect to recreational importance, ten species comprise the bulk of the party boat catch. These are the white sea bass, yellowtail, albacore, barracuda, bonito, Pacific mackerel, halibut, rockfish (a variety of species), and kelp and sand bass. (Ref. 505.)

Kelp beds are an important and highly productive habitat for a variety of algae, invertebrates, fish, birds and mammals. Kelp beds act to break up wave surges and retard shoreline erosion. Kelp forests offer marine animals refuge and food and serve as nursery grounds for young fish including sport fish such as sheephead (Pimelometopon pulchrum), kelp bass (Paralabrax clathratus), giant sea bass (Stereolepis gigas), rockfish (Sebastes spp.), and several perch. (Ref. 505.)

Fauna associated with man made structures consists primarily of rocky bottom species. Because of vertical relief and attached invertebrates, oil platforms attract many schooling and aggregating water column fishes. In contrast, water column fish are not frequently observed at similar depths along outfalls. Presence of schooling fish near oil platforms proably helps support an abundant ling cod (Ophiodon elongatus) population at the platforms; this large ambushing predator has not been observed along the outfall pipes. Because the outfalls extend to depths of 60-100 meters, and the platforms studied are at 30 meter depths, the outfall fauna contains more deep water species, in particular rockfishes such as the bocaccio (Sebastes paucispinis), and shortbelly rockfish (Sebastes jordani). Many of the fishes found at both structures can contribute to the sport fishery. Young and subadult rockfishes, kelp bass, and perch are abundant and will presumably add to the sport fishery. It has been estimated that about one-quarter of the fish seen at each structure were of suitable size for fishing. (Ref. 531.)

A variety of marine fish inhabit bottom and near bottom waters of the coastal basins. Most of the species are restricted to the deeper cold dark waters and are rare on the mainland shelf. However, some species, in large numbers, undertake daily vertical migrations. (Ref. 530.)

While some information is known about deep water species and their general distribution, very little is known about overall abundance and specific abundances in the Santa Monica-San Pedro Basin. Review of available information and field survey indicates that midwater (100-800 meters) fauna are less abundant (10-10,000 times) than epipelagic fauna. Most common fish include lantern fish (Myctophidae), light fishes (Gonostomatidae), and deep sea smelts (Bathylagidae). At least four faunal zones can be distinguished -- upper mesopelagic (above 200 meters), middle mesopelagic (200 - 500 meters), lower mesopelagic (500-700 meters) and bathypelagic (below 700 meters). Identified invertebrates are dominated by several types of shrimp, copepods and euphausids. Table 9 lists the most common species taken from San Pedro Basin. (Ref. 530.)

The data base describing midwater fauna of the deep basins is weak. Few samples have been taken and identified from the area of interest (i.e., Santa Monica-San Pedro Basin below 500 meter depth). Available samples have generally excluded quantitative information on the nearly 25 families of fishes known to contain large species. As a consequence estimates of total fish or decapod population sizes in the basins cannot be extrapolated from existing catch data. It is, however, evident that the water column of the Santa Monica-San Pedro Basin is not devoid of marine life. (Ref. 530.) Crude estimates of biomass in lower midwater depth ranges of the Santa Monica-San Pedro Basin are given in Table 10.

Benthos

Benthic organisms live immediately above, on, or in the sediments. In general such organisms are less mobile than free swimming fish or plankton and are more subject to the effects of the physical, chemical, and biological conditions in a particular area. (Ref. 501.)

Benthic organisms are important members of the marine ecological system. They affect and are affected by the distribution of chemicals and materials in the sediments. They are subject to fallout of materials from overlying waters and may concentrate substances from their environment, in some cases transforming these substances into innocuous or more noxious forms.

Many of the benthic organisms are planktonic at some stage in their life cycle, and in this form, are a food source for other biota; most are also a food source in their adult stage. (Ref. 501.)

In general the sessile, creeping, and burrowing organisms of the benthic community can be classified as follows:

TABLE 9

COMMON MIDWATER SPECIES FROM SAN PEDRO BASIN

Upper Mesopelagic (above 200 m)	
Fishes:	
Cyclothone signata	Gonostomatidae
Triphoturus mexicanus	Myctophidae
Diogenichthys atlanticus	Myctophidae
Diaphus theta	Myctophidae
Invertebrates:	
Sergestes similis	Decapod shrimp
Sergestes edwardsii	Decapod shrimp
Abraliopsis hoylei	Cephalopod
Histioteuthis heteropsis	Cephalopod
Middle Mesopelagic (200 - 500 m)	
Fishes:	
Leuroglossus stilbius stilbius	Bathylagidae
Stomias atriventer	Stomiatidae
Lampanyctus ritteri	Myctophidae
Invertebrates:	
Pasiphaea chacei	Decapod shrimp
Galitheuthis phyllura	Cephalopod
Lower Mesopelagic (500 - 700 m)	
Fishes:	
Holtbyrnia melanocephala	Searsiidae
Sternoptyx diaphana	Sternoptychidae
Melamphaes lugubris	Melamphaidae
Invertebrates:	
Gennadus propinquis	Decapod shrimp
Sergestes phorcus	Decapod shrimp
Gnathophausia ingens	Mysid shrimp
Chiroteuthis sp.	Cephalopod
Bathypelagic (Below 700 m)	
Fishes:	
Cyclothone acclinidens	Gonostomatidae
Melanostigma pammelas	Zooarcidae
Invertebrates:	
Pasiphaea emarginata	Decapod shrimp
Hymenodora frontalis	Decapod shrimp

Source: Mearns, Alan J., et. al., "Biological Conditions in Santa Monica and San Pedro Basins", Report to LA/OMA Project, Southern California Coastal Water Research Project, (April 28, 1978).

TABLE 10

MIDWATER FAUNA BIOMASS IN LOWER DEPTH RANGES OF SANTA MONICA - SAN PEDRO BASINS

	Lower Upper Basin	Lower Basin
Depth range	600-740 m	740-900 m
Volume	$3.6 \times 10^{11} m^3$	$2.9 \times 10^{11} m^3$
Number density	$32/10^4 m^3$	$32/10^4 m^3$
Total Number in Volume	1×10^9	9×10^8
Biomass Density	$10g/10^4 m^3$	(a)
Total Biomass in Volume	$4 \times 10^8 g$	(a)

Source: "Draft Final Report, Assessment of Alternative Ocean Sludge Disposal Practices", Jackson, George et.al, (December 1978).

Note: Animal densities obtained from 1977 survey by Southern California Coastal Water Research Project.

(a) No data but assumed small relative to benthic fauna.

- Invertebrate animals living in the substrate (infaunal) or on the substrate (epibenthic),

- Sessile plants attached to hard substrate, and

- Demersal and near-bottom dwelling fish.

While these categories together comprise the benthic community and the subdivisions are suitable for purpose of discussion, the boundaries are not well-defined and overlaps exist.

Benthic invertebrates are sometimes classified according to size as: macro (greater than 1 mm in diameter), meso (1 mm to 0.1 mm), or micro (less than 0.1 mm) (Ref. 502).

Benthic communities vary according to substrate characteristics. Greatest biomass is found on hard substrate. Although less biomass is found on soft substrate, a dense and varied population may be found in such areas -- for the most part beneath the sediment surface. (Ref. 501.)

Dominant members of benthic communities are not always uniformly abundant. Community composition changes with depth, the most important variable, sediment particle size, content of organic material and other factors. (Ref. 504.)

Nearshore Intertidal

Organisms in this nearshore zone are subjected to desiccation, temperature extremes, salinity variation, and physical disturbance by sand and wave action. Relatively few organisms are capabale of withstanding the waveshock and shifting substrate of turbulent sandy beaches.

The limited number of animals present include small arthropods such as sand crabs or beach hoppers and molluscs such as clams. Burrowing is common. Food availability and physical conditions largely determine the location and density of populations. There is very little primary productivity in sandy reaches since there are few algae or phytoplankton; food is generally in the form of drift kelp, planktonic algae, and invertebrates which are washed ashore or trapped between grains of sand. The surf zone, where wave action stirs up food organisms, attracts a few fish such as the surf perch, croakers, California corbina, and the shovelnose guitarfish. Grunion use the sandy beaches during extreme high tides for spawning. They deposit their eggs in the sand to incubate until the next extremely high tide returns the newly hatched grunion to the sea. (Ref. 505.)

In rocky intertidal areas, animals situate themselves in vertical zones depending upon the relative duration and periods of tidal exposure and wave shock. The rocky intertidal area supplies shelter and food for a diversity of mobile and attached fauna and a highly productive algal community. Macroscopic algae and eelgrass are abundant as are the microscopic algae which are attached to the rock surfaces. Tide pools trap a variety of organic material which supports many organisms including species of annelids, arthropods, molluscs and echinoderms. (Ref. 505.)

Mussels, barnacles, and limpets are usually abundant in shallow tide pools while starfish, sea urchins, and octopuses live in the deeper tide pools. Due to overzealous collectors scouring the tide pools, overturning rocks, and gathering numerous animals which die after being removed from their habitats, the number and variety of local tide pool organisms have declined. Marine life refuges have been created and are patrolled to assure that laws against collecting non-game organisms are enforced. (Ref. 505.)

Nearshore Subtidal

Subtidal regions, since they are constantly submerged, contain the most productive areas. Within the subtidal, rocky (hard) substrate areas support kelp beds which in turn harbor and feed a variety of organisms.

In sandy shallow portions of the mainland shelf (3-9 meters depth), waves stir up the substrate creating an environment more harsh to benthic organisms than in slightly deeper water. The invertebrates that occur in these shallow areas include those that construct flexible tubes such as the polychaete, Loimia medusa; those that occupy deep burrows such as the long neck clams; those that can burrow quickly such as the sand crab, Blephariopoda; and those that have adaptive shapes such as the lancelet, Branchiostoma, the polychaetes, Prionospio, Ophelia, and Nephtys, and the peanut worm, Sipunculus. (Ref. 502.)

Pismo clams (Tivela stultorum) are abundant in the shallow subtidal areas stretching from Seal Beach to Newport Beach. They are taken for human consumption during the normal clamming season (October through February), when unusually low tides occur during daylight hours. Cockles are taken from rocky tidal reaches or sandy reaches of tidal inlets.

Benthic Infauna: Over 4,500 species of invertebrate animals live in large numbers in the substrate that covers the mainland shelf of Southern California. The diversity of species is generally dominated by small crustaceans (mainly amphipods and ostracods) and polychaetes but also includes a variety of small clams, snails, echinoderms, and others. Brittlestars, such as Amphiodia urtica, and certain polychaetes, clams, and snails are representative of the most common benthic populations on the mainland shelf. (Ref. 504.)

In 1977, SCCWRP conducted a survey which covered stations located at 10 kilometer intervals between Point Conception and the U.S./Mexico border. Principal objectives of the survey were to define what can be considered the normal condition of sediment chemistry and benthic community structure at the 60-meter depth, the average depth of discharge of the large wastewater outfalls in the Southern California Bight. Over 37,000 specimens of 710 species of animals were found in 71 benthic 0.1 sq. m. grab samples collected during the 60-meter survey. Generally, the fauna were dominated by polychaets (303 species), crustaceans (194 species), molluscs (135 species) and echinoderms (30 species). No sample was devoid of life although there were large variations in abundance of individual species. (Ref. 532.)

Benthic infaunal characteristics at the control stations from the 60-meter survey are shown in Table 10. The 0.1-square-meter grab samples average 71 species of animals, 423 individuals, and a biomass of 7 grams. It is believed that the ranges of control values are valid only for depths between 20 and 200 meters. In shallower or deeper sediments, control conditions for these chemical and biological parameters may differ. (Ref. 532.)

Demersal Fishes and Epibenthic Invertebrates: Nearly 190 species of fishes, sharks, and rays and 390 species of epibenthic invertebrates are known to live on or just above the bottom along the Southern California mainland shelf. Community components include various species of flatfish, rockfish, poachers, perch, sculpins, shrimp, crabs, sea urchins, starfish, and sea cucumbers. As with the benthic infauna, these animals form loose associations which are dominated by a few characteristic species. For the most part, these animals are highly dependent on the infauna and each other as food sources; many are also dependent on the bottom for refuge and camouflage. (Ref. 504.)

Like the infauna, demersal fish and epibenthic invertebrate communities vary in abundance and composition with season, depth, and proximity to various types of bottom. For example, there are clear changes in the composition of fish, shrimp, and echinoderm catches with depth. Many species which look alike (or are closely related in habits) appear to replace one another as the depth changes. (Ref. 504.)

Based upon studies through 1975, an average 10-minutes otter trawl on the mainland shelf captured about 175 fish representing about 11 species weighing 7.1 kilograms, with an average Shannon Weaver diversity of 1.36. (Ref. 504.)

Fifty-three trawl samples taken during the 1977 SCCWRP 60-Meter Survey contained over 23,500 specimens of vertebrates (representing 64 species and 22 families of sharks, rays, and bony fishes) and 20,400 specimens of invertebrates (representing 224 species). Catches were domianted by rockfish (Sebastes spp., 129 species) and bothid and pleuronectid flatfish (6 species in each family). Among the invertebrates taken were 57 species of crustaceans (including crabs and shrimp), 65 species of molluscs (including octopus, squid, bivalves, etc.) and 23 species of echinoderms. The most abundant species in the trawl samples are listed in Table 12 which includes, in some instances, catches of large numbers of small (recently recruited) fish and invertebrates. (Ref. 532.)

TABLE 11

BENTHIC INFAUNAL CHARACTERISTICS FROM THE 60-METER SURVEY

1977

Biological Characteristics (per 0.1 square meter)	Control Values			Range of Values	
	Mean	95% CL[(a)]	No. of Stations	Control Stations	All Stations
Total					
No. of Species	71	64-78	29	40-124	32-167
No. of Individuals	423	375-471	29	229-654	91-3,057
Arthropods					
No. of Species	21	18-24	29	8-34	2-43
No. of Individuals	61	50-72	29	19-124	2-271
Molluscs					
No. of Species	13	12-14	29	9-19	5-23
No. of Individuals	44	37-51	29	24-83	6-1,004
Echinoderms					
No. of Species	5	4-6	29	2-9	0-10
No. of Individuals	141	104-178	29	9-365	0-365
Polychaetes					
No. of Species	26	22-30	28	13-58	11-68
No. of Individuals	136	110-162	28	62-367	15-1,964
Miscellaneous phyla					
No. of Species	6	5-7	29	2-12	2-28
No. of Individuals	35	27-48	29	7-110	3-110
Infaunal Trophic Index	93.5	91.6-95.4	24	83.1-98.3	21-99
Shannon Weaver diversity	3.05	2.89-3.21	27	2.19-3.98	1.34-4.16
Species dominance[(b)]	6.4	5-8	27	2-16	2-18
Individuals/Species	5.9	5.3-6.6	27	3.6-10.1	3.1-39.2
Biomass (grams)	7.0	6.1-8.0	29	2.8-11.2	1.5-70.7

Source: Southern California Coastal Water Research Project Annual Report, (1978).

(a) 95% confidence limits.
(b) Minimum number of species required to account for 60% of the individuals in a sample.

TABLE 12

DEMERSAL FISH AND BENTHIC INVERTEBRATES SPECIES FROM THE 60-METER SURVEY

1977

Common Name	Species Name	Number of Individuals
Urchin	*Lytechinus anamesus*	10,801
Stripetail rockfish	*Sebastes saxicola*	8,074
Pacific sanddab	*Citharichthys sordidus*	5,895
Ridgeback prawn	*Sicyonia ingentis*	5,663
Calico rockfish	*Sebastes dalli*	2,812
Plainfin midshipman	*Porichthys notatus*	1,507
Sandstar	*Astropecten verrilli*	1,478
Speckled sanddab	*Citharichthys stigmaeus*	1,076
Yellowchin sculpin	*Icelinus quadriseriatus*	736

Source: Southern California Coastal Water Research Project Annual Report, (1978).

Data on demersal fish and invertebrates at the control stations from the 60-Meter Survey are shown in Table 13. These ranges of control values are believed to be valid only at depths between 20 and 200 meters. (Ref. 532.)

Coastal averages in biological parameters can be misleading if they do not reflect normal geographic trends. For example, the 60-Meter Survey indicated a significant trend of decreasing fish abundance and increasing fish diversity along the coast from north (Point Conception) to south (U.S./Mexico border). Therefore, Table 13 also separates data into "northern" (Point Dume vicinity and north) and "southern" (Laguna Beach vicinity and south) control sites. (Ref. 504, 532.).

Long term fluctuations of fish catches appear to be largely dependent on overall recruitment success. During some years, certain species such as sanddabs (Citharichthys spp.) and rockfishes (Sebastes spp.) have had very successful recruitment of juveniles from the plankton. Other species may be on biennial cycles. (Ref. 504.)

Sessile Plants: The dominant kelp beds along the Southern California Coast are formed by Macrocystis pyrifera, bounded toward the shore by Egregia. Between the intertidal area and the inner fringes of the kelp occur surf grass (Phyllospadix) and several medium-sized brown algae (Eisenia, Pterygophora, Laminaria, and Desmarestia). Beneath these plants grow numerous smaller green, brown, and red algae. Major kelp beds are located along the northern shoreline of Santa Monica Bay, along Palos Verdes Peninsula, and other coastal locations and offshore islands removed from the Los Angeles/Orange County Metropolitan Area. (Ref. 502.)

Many factors control the distribution of kelp. These include substrate, grazing, light penetration, encrusting growths, sedimentation rates, shifting sands, inter and intraspecific competition. Temperature may also play a role in controlling kelp abundance. For example, it has been found that different strains of Macrocystis pyrifera tolerate different maximum temperatures, depending on their natural thermal ranges. M. pyrifera, indigenous to the Los Angeles area, may thrive only at temperatures less than 20°C, whereas individuals of the same species collected several hundred miles south grow luxuriantly at 26°C. During the period 1957 through 1959, unusually warm water persisted throughout the year causing most kelp of Southern California to deteriorate, and some beds even disappeared. Along Palos Verdes, the beds have been showing some regrowth in the past 2 to 3 years, due to intensive management by the California Department of Fish and Game Kelp Management Program. (Ref. 502.)

Kelp undergoes cyclical natural succession along the coast of Southern California (except at Santa Barbara) during which all or part of a kelp bed dies off and new plants grow up. Grazers such as sea urchins, however, can destroy a kelp bed and prevent its return. For instance, the sea urchins, Strongylocentrotus franciscanus and S. purpuratus were found to have dense populations ($\geqslant$50

TABLE 13

CHARACTERISTICS OF DEMERSAL FISH AND INVERTEBRATES FROM THE 60-METER SURVEY

1977

	All Stations (53)(a)	Control Stations		
		All Controls (28)(a)	Northern Controls (16)(a)	Southern Controls (12)(a)
Fish				
No. of Individuals				
Median	242	378	515	225
95% CL	186-347	186-623	177-1,005	158-440
No. of Species				
Median	15	14.5	14	14.5
95% CL	13-16	12-16	11-18	12-19
Biomass(kg)				
Median	4.4	4.7	10.9	4.0
95% CL	3.2-5.2	3.2-7.9	3.2-9.1	2.55-10.2
Shannon-Weaver Diversity, H				
Median	1.56	1.38	1.25	1.58
95% CL	1.41-1.68	1.22-1.57	1.11-1.53	1.31-2.00
Invertebrates				
No. of Individuals				
Median	198	181	170	191
95% CL	136-308	90-351	80-483	29-351
No. of Species				
Median	11.5	10.5	14.5	7.5
95% CL	10-14	7-14	10-16	5-10
Biomass(kg)				
Median	6.0(b)	7.4(c)	12.2	2.25
95% CL	3.1-12.5	2.5-12.5	5.2-15.1	1.7-4.2

Source: Southern California Coastal Water Research Project Annual Report, (1978).

(a) Number of stations.
(b) Based on data from 40 samples.
(c) Based on data from 20 samples.

per sq. m. at Palos Verdes) in areas where kelp beds formerly occurred, and these high densities hinder kelp re-establishment by cropping young sporophytes (Ref. 563). Removal of the urchins allowed kelp and other vegetation to grow in this area. The increase in the urchin population may be related to removal of urchin predators, depletion of abalone (food and substrate competitor), and nutrient sewage discharges. (Ref. 502.)

Giant kelp stipes have been observed to grow from 30 to 61 cm/day (12 to 24 inches/day) during periods of optimal conditions of clear cool water (below 20°C) when nutrients are not limiting. It has been reported that the annual production of a "good" kelp bed is about 15.0 metric tons/hectare/year. (Ref. 502.)

The various invertebrates of kelp beds are supported in their respective niches by several factors:

- Primary production of the kelp provides food for herbivorous invertebrates,
- The kelp structure provides vertical relief and a substrate for encrusting organisms, primarily filter feeders,
- Shelter is also provided, especially for organisms relying on camouflage for protection and food acquisition, and
- Animals avoiding light are drawn to the shade of kelp beds. (Ref. 502.)

A number of invertebrates depend indirectly on the kelp bed for sustenance. These are sessile suspension-feeders, carnivores, and scavengers. The sessile invertebrates may colonize the fronds, stipes, and holdfasts of the kelp or the sea floor below the kelp. The benthic invertebrates found underneath the kelp are usually older than those which have colonized the kelp because of the greater stability of the hard substrate. Common types of kelp bed suspension-feeders are ectoprocts, hydroids, crustaceans, and sponges. Less common suspension-feeders are pelecypods, gorgonian corals, and polychaete worms. Invertebrate herbivores, intermediate in the trophic structure of the food web, are sea urchins and gastropod molluscs such as abalone and other snails, while carnivores include scyphozoans, starfish, cephalopods, crustaceans, and anthozoans. Scavengers include polychaetes, sea urchins, holothurians, anthozoans, crustaceans, gastropods, and starfish. (Ref. 502.)

Man-made Structures: Fauna associated with man-made structures (oil platforms and outfall pipes) consists primarily of rocky bottom species. Dominant organisms on both structures include attached suspension-feeding invertebrates (mussels, hydroids, gorgonians, and anemones), motile scavenging invertebrates (crabs, shrimp, starfish, and gastropods) and fishes that seek refuge in rock holes and crevices (sculpins, bottom-living rockfishes, and greenlings).

Away from both structures, the dominant soft bottom species are suspension feeding invertebrates (sea pens, tube anemones, polychaetes, and clams), motile scavenging invertebrates (crabs, shrimp, starfish, gastropods, sea urchins, and sea cucumbers) and benthic fishes (flatfishes, sculpins, combfishes, and benthic rockfishes). Although many families and classes are represented on both rocky and soft bottoms, the species occuring in each habitat are usually different. (Ref. 531.)

Differences in faunal composition are related to the depth range covered by each of the structures. The most abundant shallow-water, bottom living rockfish at the platforms and outfalls was the brown rockfish (Sebastes auriculatus). The California mussel (Mytilus californianus), commonly found intertidally, is the dominant sessile organism on the platforms at depths from the surface to 8 meters but are not found on outfall pipes at depths greater than 10 meters. The large white sea anemone (Metridium senile) is found on the lower parts of the platforms from 12 to 20 meters but occur along the outfall pipes at depths greater than 50 meters. The anemone feeds on particulates suspended in the water column, and the dense populations along the outfall pipes may be feeding on suspended sewage particulates. Because outfalls extend to depths of 60-100 meters and the oil platforms studied are at 30-meter depths, the outfall fauna contains more deep water species, in particular, rockfishes such as bocaccio (Sebastes paucispinis), vermilion rockfish (Sebastes miniatus), and shortbelly rockfish (Sebastes jordani). (Ref. 531.)

Deep Basins and Submarine Canyons

Between October 4 and December 1, 1977, SCCWRP conducted surveys of demersal fish, epibenthic and benthic infauna at eight locations in the San Pedro and Santa Monica Basins ranging in depth from 525 to 915 meters. At each location, a bottom trawl, a bottom grab sample, and water samples (for determination of temperature, salinity and dissolved oxygen) were taken. In addition a 35 mm baited camera was used to photograph the bottom and marine life at three of the sampling locations. (Ref. 530.)

The biological sampling in this program was designed to add to the sparse existing data base. While much more work needs to be done for a proper quantitative assessment, there are, nevertheless, some important general trends that have been confirmed. (Ref. 530.)

First, the water column and sediments of San Pedro and Santa Monica Basins are not devoid of marine life. At the deepest depth sampled (915 m) there were few live organisms taken. One fish and seven epibenthic invertebrate species were collected in the trawl; three invertebrates (with a total biomass of 0.5 gm per sq. meter) were taken in the sediment grab. (Ref. 530).

Second, while the fauna is lower in abundance and diversity below sill depth (737 m) than above, there appears to be no great sudden drop or faunal discontinuity at sill depth, but rather a gradual decline in abundance of most organisms. This suggests that there are no significant physical or chemical discontinuities. (Ref. 530.)

When the entire depth range of the mainland shelf, slope, and basins is considered, there are some discontinuities in abundance and number of species. For example, previous sampling indicates that epibenthic invertebrate abundance and biomass increases from 20 to 450 meters and then declines at greater depths. In most coastal areas at this depth (450 m), irregular sea urchins (such as Brissaster, Brissopsis, Spatangus) form dense beds and are the major contributors to high invertebrate biomass. Off Palos Verdes, however, this echinoderm fauna is depleted to a depth of at least 600 meters possibly due to outfall effects. (Ref. 530.)

The abundance and variety of fishes on the coastal shelf is about twice that encountered in basin trawls. This trend is consistent with Ref. 533 which also suggested that fish abundance and variety begins its decrease with depth between 200 and 300 m. That report also indicated that peak biomass of bottom fish occurs at between 200 and 400 meters, and maximum fish size occurs at 460 meters. (Ref. 503.)

The infauna reflects the depth-related trends seen in the epibenthic fauna at depths greater than 450 m. The infauna appears to gradually decrease from an average of 2500 animals per square meter at 60 meters depth, to an average of 88 animals per sq. m. below sill depth. The number of species and biomass follow this trend. More importantly, however, are changes in community composition and occurrences of unique organisms. For example, beyond the urchin dominated community at 450 m. the basins appear to be fringed with dense concentrations of empty polychaete tubes. Hartman and Barnard described this association of empty Phyllochaetopterus tubes as depauperate. (Ref. 534). However, the tubes are reported to contain a variety of other living invertebrates (e.g., dense aggregations of the small snail Mitrella permodesta. (Ref. 530.) Crude estimates of benthic biomass in different depth ranges of the Santa Monica-San Pedro Basin are given in Table 14.

Benthic Infauna: A total of 50 species of invertebrates were identified from the eight grab samples. Polychaetes were the most diverse group with 24 species. There were also seven species of arthropods, six of echinoderms, five of molluscs, four of coelenterates, and three other phyla (Nemertea, Nematoda, Chaetognatha). The number of species per 0.1 square meter sample varied from 2 to 16. The number of individuals varied from 30 to 600 per square meter while biomass ranged from 0.5 to 34.3 g/sq. meter and Shannon-Weaver diversity from 0.95 to 2.4. In general, the number of species, individuals, total biomass, and diversity were all less below sill depths than above. (Ref. 530.)

TABLE 14

BENTHIC BIOMASS IN DIFFERENT DEPTH RANGES OF SANTA MONICA - SAN PEDRO BASIN

	Lower Upper Basin	Lower Basin
Depth Range	600-740 m	740-900 m
Benthic Area	$0.6 \times 10^9 m^2$	$2.5 \times 10^9 m^2$
Epibenthic Fauna (a)		
Biomass Density	31 kg/haul	0.86 kg/haul (b)
Total Biomass in Area	$2 \times 10^9 g$	$2 \times 10^8 g$
Benthic Fauna		
Biomass Density	$15 g/m^2$	$4 g/m^2$
Total Biomass in Area	$9 \times 10^9 g$	$10 \times 10^9 g$
Total Biomass in Range	$11 \times 10^9 g$	$10 \times 10^9 g$

Note: Animal densities obtained from 1977 survey by Southern California Coastal Water Research Project.

(a) Epibenthic densities calculated assuming that the otter trawl sampled $10^4 m^2$ per haul (calculated for a net 7.6 m wide, towed for 20 minutes at 2 kts).

(b) Fish only.

These results compare closely with those of Hartmann and Barnard (Ref. 534) who took 33 benthic samples below sill depth in the San Pedro Basin between 1952 and 1954. Average density calculated from these samples was 83.5 animals per sq. meter (compared to the SCCWRP study mean of 87.5). The average biomass from the SCCWRP study was slightly lower (4.0 compared to 9.2 g/sq. meter) (Ref. 530.)

Demersal Fish and Epibenthic Invertebrates: A total of 82 taxa of fishes and invertebrates, comprising over 7,243 individuals, were taken in the eight trawls. There were 683 fish, representing 19 species and 24 families, and over 6,560 invertebrates representing 63 taxa and seven phyla. (Ref. 530.)

The most abundant and common fish were the longspine thornyhead Sebastolobus altivelis, with 451 specimens at 7 of the stations, and the California rattail Nezumia stelgidolepis, with 71 specimens at 4 of the stations. The next most abundant and common fishes were shortspine thornyhead (Sebastolobus alascanus), sablefish (Anoplopoma fimbria) and brown cat shark (Apisturus brunneus). Dover sole (Microstomus pacificus), common in shallower waters, were captured at two stations. The bottom trawls collected a few specimens of various midwater fishes including lanternfish (Lampanyctus mexicanus, Stenobrachius leucopsarus, and unidentified myctophids), blackbelly dragonfish (Stomias atriventer) and a midwater eelpout (Melanostigma pammelas). (Ref. 530.)

While numerous invertebrates were captured, few species were common to most trawl sites and large catches of single species occurred at only one or two sites. Keeping this fact in mind, the most abundant animal was a small snail (Mitrella permodesta, over 3,000 individuals), a brachyuran crab (Munidopsis hystrix), a heart urchin (Brissopsis pacificus, 528 specimens), the shrimp Spirontocaris sica), the starfish (Myxoderma sp.) and the sea cucumber (Pannychea mosleyi). These last three species were abundant at two or three of the eight sites. (Ref. 530.)

Most of the species are unique to the depth range sampled (550 to 915 meters) and to somewhat shallower waters. A few do occur occasionally in trawls on the mainland shelf (to 200 m); these include sablefish, Dover sole, hagfish, and shortspine thornyhead, the clam (Macoma carlottensis), the pelagic red crab (Pleuroncodes planipes), the hydrozoan (Dromalia alexandri), and the sea star (Rathbunaster californicus). (Ref. 530.)

Extremely large accumulations of empty tubes of the shallower water polychaete Spiochaetopterus together with abundant Mitrella permodesta snails occurred at several basin sites on the lower edge of the rapid slope off Palos Verdes. This indicates that coastal shelf debris not only falls into basin depths but also accumulates in certain areas. (Ref. 530.)

- Baited Camera Observations

  Five species of fish and some ten species of large invertebrates were observed. Pacific hagfish and sablefish were common at all locations.

Rattails, shortspine thornyheads, and Dover sole were seen only at the rise separating Santa Monica and San Pedro Basins. (Ref. 530.)

A variety of brittle stars and starfish were observed (one or two species per station. One or more species of shrimp were also seen at deeper sites and at a station at the 600 m depth off Palos Verdes. Photographic slides revealed hundreds of small gastropods (probably Mitrella permodesta) scattered over the bottom and, eventually, on the bait. (Ref. 530.)

The camera recorded fewer species than did the trawls. However, the photographs did indicate that hagfish may be much more common in the basins than indicated by their low abundance in otter trawls. This difference in abundance may be explained by the copious mucous secretion of the hagfish and their extreme agility, possibly allowing easy escape through the mesh openings in the trawl nets. (Ref. 530.)

The bottom at all locations consisted of a dark green or brown silt which was easily suspended by the apparently active hagfish and sablefish. Suspended material appeared to either settle rapidly or drift out of the field of view between consecutive photographs taken at 15 minute intervals. Mainly, however, the water at all sites was exceptionally clear with horizontal visibility greater than 8-10 meters (edge of strobe light pattern). (Ref. 530.)

Submarine Canyons: Submarine canyons extending from near the coastline to the deep basins contain a unique and varied fauna. Canyon habitats are subject to considerable fluctuations in environmental conditions because they serve as channels for shoreward movement of upwelling waters and for downward transport of runoff sand and debris. These processes result in widely (and often suddenly) varying conditions to which the indigenous fauna must adjust. In general, variety and numbers of animals decrease with depth. In all of the canyons examined, polychaetes represented the largest proportion of the total number of species; crustaceans and molluscs were present in fewer numbers. Estimates of biomass in the canyons are given in Table 15. This table shows that canyons are intermediate in standing crop between the deep basins and coastal shelf. The average biomass is about 175 g/square meter. (Ref. 501.)

Air/Water Interface

Organisms at the air/water interface of the marine environment are found on or very near the surface of the water or periodically surface for oxygen. Marine and shore birds and marine mammals are the most significant groups of organisms. Planktonic organisms (neuston), insects, free floating kelp or other debris with attached organisms also occur at this interface.

Birds

Marine and shore birds are associated with ocean (pelagic, littoral, and bays) and shoreline (rocky shore-sea cliff, sandy beach, and Channel Islands) habitats

TABLE 15

ESTIMATED MEAN BIOMASS IN CANYONS

(grams per square meter)

Canyon	Biomass
Hueneme	275
Magu	154
Dume	145
Santa Monica	43
Redondo	367
San Pedro Sea Valley	88
Newport	151

Source: Southern California Coastal Water Research Project "The Ecology of the Southern California Bight: Implications for Water Quality Management", (March 1973).

in Southern California. The number of species found in the ocean habitat are: pelagic, 33 species; littoral, 55 species; and bays, 46 species. The shoreline habitat species are as follows: rocky shore-sea cliff, 27 species; sandy beach, 35 species; and Channel Islands, 118 species plus 18 endemic subspecies. Salt marshes, estuaries, and tidal areas along the coast are also utilized by marine as well as some freshwater and terrestrial birds. (Ref. 502.)

The marine and shore birds found in Southern California occur as permanent residents or as migratory visitors. Many breed on the Channel Islands. Population levels in all habitats fluctuate seasonally as the migratory species pass through or stop in the area. Aerial surveys of 2,784 km in the Santa Barbara area during 1968 showed a population of 12,000 birds in February and March; and 85,000 birds in April and May. (Ref. 502.)

Mammals

The marine mammals of Southern California, including those at the Channel Islands, consist of cetaceans (whales, porpoises, and dolphins), pinnipeds (seals and sea lions), and carnivores (an occasional sea otter). (Ref. 502.)

The southern California coast and adjacent islands are the most important breeding and hauling out grounds along the Pacific Coast of the United States (except Alaska) for pinnipeds, and over twenty species of cetaceans frequent the area. The abundances of cetaceans in Southern California waters vary widely. All of the Mysticeti (baleen whales) are transients in the area with only the California grey whale occurring frequently. Blue and humpback whales may occur off the southern California coast, but no confirmed sightings are recorded. The five most abundant Odontoceti (toothed whales, porpoises, and dolphins), from Point Conception to Ensenada in descending order of occurrence, are the common dolphin, the Pacific white-sided dolphin, the northern right whale, the Pacific pilot whale, and the combined Dall porpoise/Pacific bottle-nose dolphin. (Ref. 502.)

The most abundant pinnipeds are the California sea lion, the northern elephant seal, and the harbor seal. Aerial surveys of the Channel Islands in 1964 measured 34,382 California sea lions, 2,158 northern elephant seals, and 645 harbor seals. The 1975 population estimate for the northern elephant seal is 6,000 individuals. Although the Stellar sea lion and northern fur seal are abundant in Alaska, only small colonies of approximatley 75 to 800 occur on San Miguel Island. (Ref. 502.)

The only member of the Order Carnivora to inhabit the area in the past has been the sea otter. It was exterminated from much of the California coast by fur hunters early in the 19th century; however, the population is making a comeback and now extends from Monterey to south of Morro Bay. If habitat conditions do not deteriorate, sea otters should again become established on the northern Channel Islands. (Ref. 502.)

SENSITIVE SPECIES AND AREAS

Unique ecological communities and rare and/or endangered species are found within the California Bight and along the mainland shore. Legally protected rare and endangered plants and legally established sanctuaries and preserves are included in this category.

Ecologically Sensitive Communities

Sensitive ecological communities may be found along the coastline and at the Channel Islands. Waters surrounding San Clemente, Santa Catalina, and Santa Barbara Islands have been designated as "Areas of Special Biological Significance" by the State Water Resources Control Board. In addition, it is reported that a draft environmental impact statement is being prepared by the office of Coastal Zone Management and the National Oceanic and Atmospheric Administration to support designation of the Northern Channel Islands (Anacapa, Santa Barabara (sic), Santa Rosa, Santa Cruz, and San Miguel Islands) as Marine Sanctuaries (See 44 FR 69970, Dec. 3, 1979) (Ref. 506).

Sensitive ecological areas located along the coastline from Point Dume to Newport Beach are listed in Table 16. It should be noted that large areas of this portion of the coastline provide habitat for the California least tern (Sterna albifrons) and California brown pelican (Pelicanus occidentalis californicanus) which are endangered species. Other endangered or threatened species also find habitat at specific locations within this general area. Additionally, a number of legally established state and local sanctuaries are also located here. (Ref. 535.) Significantly, no "Areas of Special Biological Significance" have been designated in the immediate vicinity of LA/OMA waste discharges.

Rare and Endangered Species

The Endangered Species Act (16 U.S.C. 1531-1543) governs activities which may impact threatened or endangered species listed most recently in 44 FR 3635-3654 (Wednesday, January 17, 1979). This list includes wildlife and plant species so designated as of September 30, 1978. Republication of the list, including additions, is required annually. The State of California also had adopted an Endangered Species Act (1970) and is required annually to summarize the status of critical species as determined by the California Fish and Game Department. (Ref. 506.)

Table 17 lists the State and Federal Status of rare and endangered species of the California marine region. It has been determined that the following endangered species are of potential concern with respect to the LA/OMA Municipal Discharges:

- California grey whale (Eschrichtius robustus) regularly migrates through the area in winter and spring,

TABLE 16

ECOLOGICALLY SENSITIVE AREAS ALONG THE COASTLINE

Area	County	CNACC No.(a)
Shoreline Areas		
Point Dume	Los Angeles	191670
Paradise Cove Marine Area	Los Angeles	191622
Palos Verdes Peninsula Shoreline	Los Angeles	191616
Palos Verdes Peninsula Marine Area	Los Angeles	191612
Palos Verdes Hills Marine Terraces	Los Angeles	191608
Point Fermin Marine Life Refuge	Los Angeles	191675
Anaheim Bay	Orange County	300160
Bolsa Chica Ecological Reserve	Orange County	300270
Inshore(b)		
Zuma Canyon	Los Angeles	192699
Malibu Canyon	Los Angeles	191312
Cold Creek	Los Angeles	190370
Tuna Canyon	Los Angeles	192090
Madronna Marsh	Los Angeles	191305

Source: Daniel, Mann, Johnson, ad Mendenhall, "Regional Environmental Evaluation", (May 1979).

(a) Identification number assigned by the California Natural Coordinating Council.

(b) Inshore area limited to the area between the coastline from Point Dume to Newport Beach and the Ventura and San Diego Freeways.

TABLE 17

RARE AND ENDANGERED SPECIES OF THE CALIFORNIA MARINE REGION(1)

Category/Species	California Population Trend(2)	Status State(3)	Status Federal
BIRDS			
California Brown Pelican	1,500+ (increase)	Endangered	Endangered
California Condor	60+ (decline)	Endangered	Endangered
Southern Bald Eagle	54+ (absent S.C.)	Endangered	Endangered
American Peregrine Falcon	30+ (decline)	Endangered	Endangered
Light-footed Clapper Rail	250 ---	Endangered	Endangered
California Least Tern	1,200 (stable)	Endangered	Endangered
Belding's Savannah Sparrow	2,200 ---	Endangered	Endangered
MAMMALS (including entire northeast Pacific region)			
California Grey Whale	11-33,000 (stable)	Protected	Protected(4)
Blue Whale	1,500 (decline)	Protected	Protected
Finback Whale	10-13,000 (decline)	Protected	Protected
Humpback Whale	1,200 (stable)	Protected	Protected
Sei Whale	37,000 (decline)	Protected	Protected
Right Whale	250 (stable)	Protected	Protected
Sperm Whale	254,000 (stable)	Protected	Protected
Southern Sea Otter	1,700+ (increase)	Protected	Protected
Guadalupe Fur Seal	2-5 (increase, 1200+ Mexico)	Rare	Protected
Northern Elephant Seal	---	Endangered	Protected
Island Fox	---	Rare	---
REPTILES			
Leatherback Sea turtle	--- (decline)	---	Endangered
Pacific hawksbill Sea Turtle	---	---	Threatened
Green Sea Turtle	---	---	Threatened
Loggerhead Sea Turtle	---	---	Threatened
Pacific Ridley Sea Turtle	---	---	Threatened

Source: "Joint Water Pollution Control Plant, Application for Modification of Secondary Treatment Requirements for Publically Owned Treatment Works Which Discharge Into Marine Waters", County Sanitation Districts of Los Angeles County, (September 13, 1979).

(1) 44-FR 3636 et seq. Jan. 17, 1979. Endangered and threatened wildlife and plants.

(2) BLM-1978. DEIS for OCS Lease Sale No. 48, Vol. I. Table II.F.6-1. Rare and Endangered Species, Point Reyes - Mexican Border.

(3) California Department of Fish and Game 1974.

(4) All marine mammals are fully protected, PL 92-522 (1972) Marine Mammal Act.

- The California brown pelican (Pelecanus occidentalis californicanus) is endemic to the area and breeds locally on the Northern Channel Islands (especially Anacapa and Santa Cruz Islands), and

- The California least tern (Sterna albifrons) resides along the shoreline but feeds generally in tidal waters of nearby bay, estuarine and marsh areas and does not usually fish in the open coastal reach. This is also the case for the light footed clapper rail (Rallus longirostris williamsoni) and Belding's savannah sparrow (Passerculus sandwicheusis beldingi). (Ref. 506.)

Several other listed species of mammals (The island fox, southern sea otter, fur seal, elephant seal, and various oceanic whales), birds (condor, eagle, and falcon), and reptiles (turtles) may historically have been inhabitants or have been occasionally sighted in remote reaches of the Southern California Bight. (Ref. 506.)

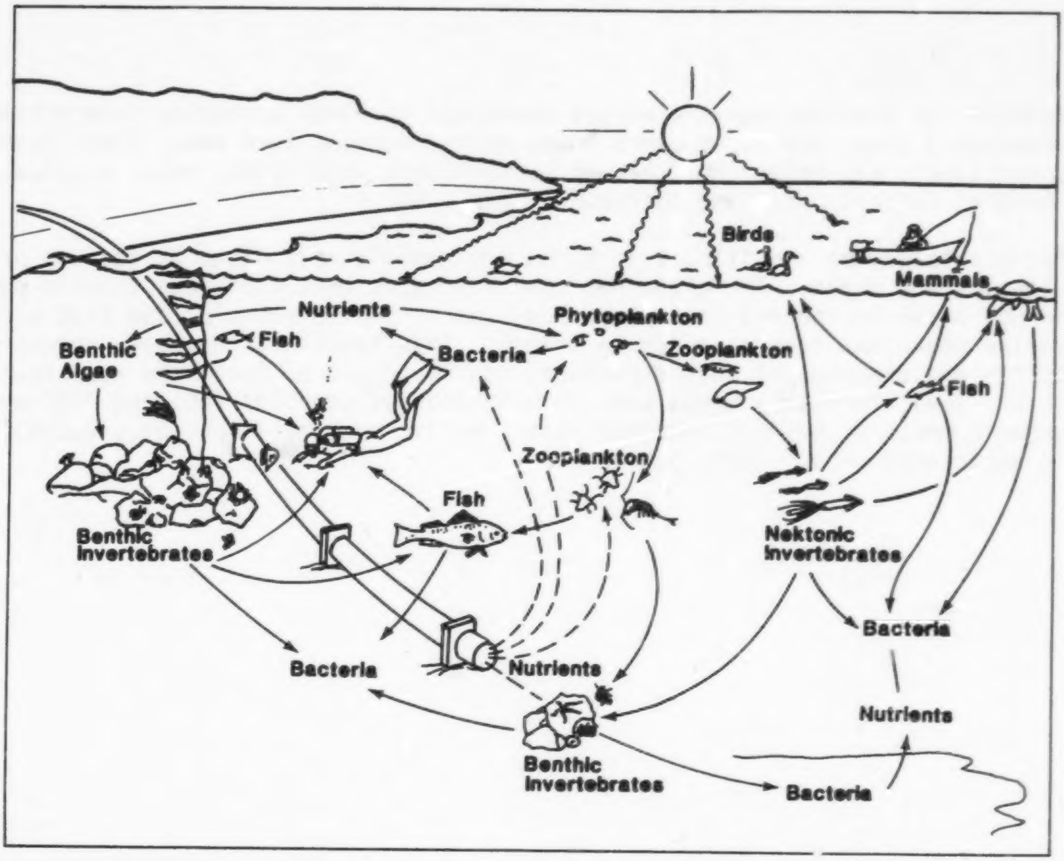
FOOD WEB

Nutrients are substances required by marine organisms, notably phytoplankton, for growth. In Southern California the nutrients that are usually limiting to phytoplankton growth are nitrogen compounds -- nitrates appear to be most important, although ammonium has been measured in limiting concentrations in Santa Monica Bay (Ref. 506). When these nutrients are added to the euphotic zone of the surface waters, the abundance of phytoplankton usually increases. Phytoplankton and benthic algae constitute the base of the marine food web, utilizing the energy in sunlight to convert carbon dioxide dissolved in the water into carbohydrates and incorporating the nitrogen and other nutrients from the water into proteins and other biochemicals. The phytoplankton that are not eaten by zooplankton, nektonic invertebrates, or fish eventually sink to the ocean floor where they provide a source of food for macro- and micro-benthic organisms directly or where they become part of the organic debris. Decompositon of the plankton or their fecal pellets by microorganisms may also occur in the water column as the organisms slowly sink towards the bottom. Phytoplankton utilize most of the nutrients that reach the euphotic zone, while those nutrients remaining below the euphotic zone may be taken up by zooplankton and other animals or may not enter the food web at all. Water below the euphotic zone is periodically transferred to the surface by the process of upwelling, which redistributes nutrients (and toxicants) throughout the water column. (Ref. 502.)

Particulate matter in wastewater effluents provides a source of nutrients for marine organisms, which could, on a localized basis, eliminate nutrient deficient conditions. The role of dissolved organic compounds as a food source for marine life is poorly understood. There is some evidence that mechanical agitation and bacterial growth are mechanisms whereby such substances enter into the food chain. Thus fine particulates that are dissolved after reaching the ocean may provide a source of fixed energy for ingestion by marine organisms. (Ref. 564.)

Transfer of food through the marine ecosystem involves a complex interaction of predators, prey, and decomposers known as the aquatic food web. (See Figure 8). Constituents may enter the food web as nutrients, toxicants, other physical and chemical constituents, and pathogens. (Ref. 502.)

Pollutants may be significant in birds and mammals which feed at the top of a classic food chain. The claim has been expressed that classical trophic pyramids do not exist in the sea (except perhaps for birds and mammals) and that most marine organisms feed at a common trough. This hypothesis has been recently tested and examples of both structured and unstructured food webs were found in the sea. The study shows that chlorinated hydrocarbons (DDT and PCB) and organic mercury, but not inorganic trace metals or "small" organics accumulate in structured webs. (Ref. 506.)



NOTE: Commercial harvesting of kelp and fish are now shown. Some pathways will vary with changing habitat types within the Bight, e.g. in areas where there is no benthic algae.

SOURCE:

Draft Environmental Impact Statement-City of Los Angeles Wastewater Facilities Plan, September 1977.

GENERALIZED REPRESENTATION OF THE FOOD WEB

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 8

BIOTIC EFFECTS FROM EXISTING OUTFALL SYSTEMS

- POLLUTANTS OF MAJOR CONCERN
- SLUDGE-SEA WATER INTERACTIONS
- POTENTIAL BIOLOGICAL RESPONSES
- REPORTED RESPONSES IN SOUTHERN CALIFORNIA

Although the evolution of the Bight has involved many large-scale ecological changes, present-day conditions are not solely the result of natural phenomena. Man has been a modifying agent for millenia and has strongly influenced the area's ecology. There are differing opinions as to the overall biotic impact exerted by past and present sport and commercial fishing; of the onshore urbanization and industrialization modifying estuarine areas; of siltation and streambed runoff; and of the develoment of large-scale regional water resources and waste treatment facilities which eventually discharge waters of variable quality (including considerable quantities of pollutants) to the Southern California Bight. (Ref. 506.)

Municipal discharges to the Southern California Bight by LA/OMA operating agencies consist of treated wastewaters and digested sludge. The City of Los Angeles operates separate outfalls for disposal of treated wastewaters and digested sludge. The County Sanitation Districts of Los Angeles County and County Sanitation Districts of Orange County operate combined (sewage and sludge) outfall systems. It is assumed that the environmental consequences associated with discharge of treated wastewaters are adequately addressed in other environmental documents (see references 502, 503, and 505). The focus of this discussion is therefore upon the effects associated with the discharge of digested sludge through ocean outfalls.

POLLUTANTS OF MAJOR CONCERN

The term "pollution" has been defined in many ways. Some have defined marine pollution as a "damaging excess" or as the introduction of substances into the marine environment that result in harm to living resources. (Ref. 544). However, State and Federal law have established the following definitions which are used in this analysis:

- Pollution means an alteration of the quality of waters of the state by waste to a degree which unreasonably affects such waters for beneficial uses or facilities which serve such beneficial uses. Pollution may include contamination. (California Water Code, Division 7, Section 13050(1).)
- Contamination means an impairment of the quality of waters of the state by waste to a degree which creates a hazard to public health through poisoning or through spread of disease. Contamination shall include any equivalent effect resulting from disposal of waste whether or not waters of the state are affected. (California Water Code, Division 7, Section 13050(k).)
- Toxic pollutant means those pollutants or combinations of pollutants, including disease causing agents, which after discharge to waters and upon

exposure or assimilation into any organism either directly from the environment or indirectly by ingestion through food chains will cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction) or physical deformations in such organisms or their offspring. (Federal Water Pollution Control Act, Section 502 (13).)

- Section 101 of the Federal Water Pollution Control Act establishes as national policy that discharge of toxic pollutants in toxic amounts is prohibited.

Many substances can be considered to be toxicants (i.e., substances that induce adverse physiological responses in organisms at certain concentrations); however, only a few trace metals and trace organic compounds have been extensively studied in the Southern California Bight.

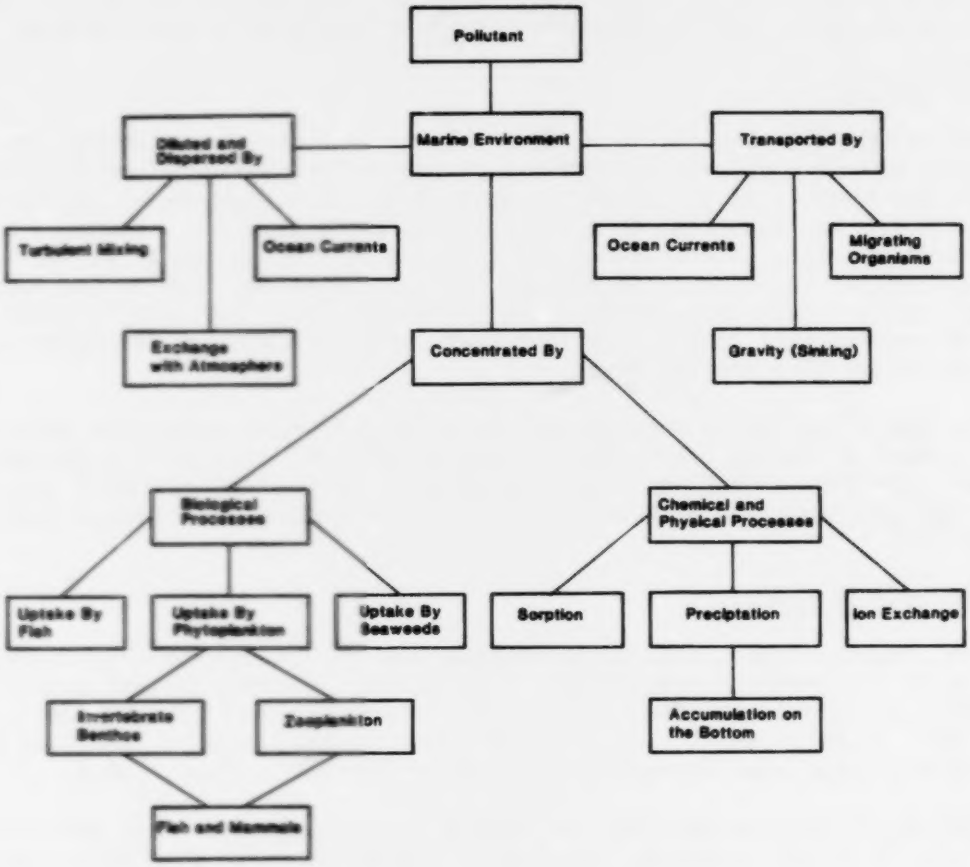
A simplified diagram of the various processes that may determine the fate and distribution of a pollutant added to the marine environment is presented in Figure 9. The waste material may be diluted, dispersed or transported by various physical processes, such as turbulent mixing, ocean currents, or exchanges with the atmosphere. It may be concentrated by various biological processes, such as direct uptake by organisms of dissolved material in the water, and it may be transferred from organism to organism in various trophic levels of the food web. Additional concentration of the material may occur at the higher trophic levels, particularly if an organ or tissue accumulates the substance. (Ref. 536.)

Substances can also be concentrated from the environment by chemical, physical, and geological processes, such as sorption. Natural waters contain a certain amount of suspended material, and some material added to the water may be sorbed on these particles. In sea water, which already contains in solution most of the known elements, added materials may be precipitated from the water column by various chemical reactions. As fresh waters carry pollutants to the sea, the change in salinity causes flocculation of some of the materials suspended in the fresh water and results in their precipitation from the water column. Ion exchange reactions with the various organic compounds dissolved in sea water can also occur. (Ref. 536.)

Marine and coastal waters constitute major sinks for persistent pollutants. Accumulation rates and steady-state levels are complex functions of input, rates of degradation, and rates of deposition in sediments. As yet no research programs have determined whether steady state conditions have already been obtained. (Ref. 536.)

Organic Matter

While subsequent discussion will focus on toxicants (in particular trace metals and trace organics) and pathogens, the organic content of sludge is also of



SOURCE:

"Water Quality Criteria - 1972",
National Academy of Sciences and
National Academy of Engineering,
(1972).

FATE AND DISTRIBUTION OF A POLLUTANT IN THE MARINE ENVIRONMENT

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 9

]

concern. The carrying capacity of the marine environment is limited, however, and environmental deterioration results from excessive organic loading.

Trace Metals

Trace metals are normally found in sea water in very low concentrations. Included in this category are metals such as cadmium, silver, lead and zinc. Many trace metals (e.g., copper, cobalt, zinc, iron, manganese) in low concentrations are essential to a healthy physiological state. However, trace elements in high concentrations are toxic to some organisms or may be concentrated and/or transformed to a state toxic to organisms high in the food web. (Ref. 501.) Some trace metals (e.g., cadmium, lead, and gold) are not known to be requirements of any life form (Ref. 538). SCCWRP has initiated studies of pollutant flow through food webs.

Organisms collected in unperturbed areas contain trace amounts of these metals. The amount of each element that induces an adverse response in organisms depends upon the element involved, the dosage, the chemical state of the element, the age and condition of the organism, and the species of organism involved. (Ref. 564.)

Trace Organic Compounds

These compounds constitute a considerable variety of chemical compounds almost all of which are synthetic materials. The majority of these organic chemicals are readily degradable to elementary materials which reenter the chemical cycles of the environment. Small quantities of such chemicals pose no long term hazard if well diluted when introduced into the environment. (Ref. 536.)

Chemicals of most concern are the stable organic compounds that persist for long periods in the environment. Laboratory studies indicate that these compounds are toxic and possibly carcinogenic to a wide variety of organisms (Ref. 564). In the LA/OMA area, attention has focused upon the chlorinated hydrocarbons -- DDT compounds, polychlorinated biphenyls (PCBs) and chlorinated benzenes.

Pathogenic Organisms

For many years, public health authorities have expressed concern over the presence of pathogenic organisms in coastal waters. In the Southern California coastal area, most of the bathing beaches are used extensively year- round by the general public. Also, shellfish are harvested in the tidal areas. There is legitimate concern that disease may be transmitted by either swimming in or consuming shellfish from waters that are contaminated by pathogenic organisms (Ref. 501, 561). Only a small fraction of the large number of bacteria and other organisms present in municipal discharges, surface runoff, and other inputs are pathogenic (Ref. 501). The overwhelming majority of the marine bacteria are essential components of the ecosystem, whose roles include degradation of organic material, nutrient cycling, and food resource for microscopic plants and animals (Ref. 504).

Viruses and pathogens discharged to the ocean by municipal outfalls are subjected to a number of antagonistic processes. Potential mortality sources include sedimentation, predation by marine bacteria and filter feeders, destruction by ultraviolet light and antiviral agents present in sea water. (Ref. 525.)

Mussels and other shellfish are efficient concentrators of bacteria and viruses. It has been estimated that it takes three to six times as long for viruses to undergo the same mortality as bacteria during their concurrent residence in the sea and concentrated in mussels near ocean outfalls. (Ref. 525.)

The danger of bacterial disease from eating uncooked shellfish is much greater than that from accidental ingestion of water by a swimmer. Further, it has been stated that the proper attitude towards eating uncooked seafood should be the same as that towards eating uncooked pork or drinking from roadside streams: the benefits derived are not worth the hazards. Chlorination does not kill all microbes. (Ref. 523.)

During winter and early spring months, when the thermocline is absent, distribution of viruses and bacteria in the water column near municipal outfalls is relatively even. During this time there is free exchange of deep and surface waters and bacteria in the plume can be detected at the surface. When the thermocline is present, bacteria and virus concentrations are low or undetectable at the surface and increase with depth. Coliforms from the Hyperion 5-mile outfall are found over a wide area of Santa Monica Bay at depths of 15 and 43 meters. Data for Orange County and Palos Verdes outfall areas generally show similar depth and dispersion charactersitics. (Ref. 504.)

SLUDGE - SEA WATER INTERACTIONS

Sludge is the liquid - solid suspension resulting from sedimentation and/or biological treatment of wastewater. Sewage sludge contains a variety of visible material and large concentrations of particulate and dissolved organic matter, major salts and nutrients, trace metals, synthetic chemical compounds, and a variety of microbial species. The liquid fraction of the sludge exhibits substantial biochemical oxygen demand, and large amounts of nitrogen and phosphorous. Typically, liquid digested sludge contains about 3 percent solids (30 g/l) and 97 percent water

Visible matter in sludge includes seeds, vegetable skins, fibers, pieces of plastic-sheeting film, metal foil, or rubber fragments, bone, fish scales, soap particles, and hair. Wet screening of sludge can remove a majority of this visible matter.

Anaerobic digestion reduces the size of sludge particles. It has been reported that while less than 50 percent of the undigested (raw) sludge produced at the Hyperion (City of Los Angeles) Treatment Plant will pass through a 53-micron hole, 70-80 percent of the digested sludge will pass through the 53-micron screen. These smaller sludge particles, which settle slowly, include bacterial cell bodies, fine cellulose, clay material, mineral precipitates such as metal sulfides, Fe_3O_4, adsorbed synthetic chemical compounds, etc. (Ref. 538.)

Data on partition between dissolved and particulate-associated metals are sparse. Results of analyses of digested sludge from Hyperion shown in Table 17 show that the fraction of metals in solution falls into two categories:

. Those less than one percent -- cadmium (Cd), chromium (CR), copper (Cu), and zinc (Zn).

. Those less than seven percent - nickel (Ni) and lead (Pb). (Ref. 538.)

Anomalous values for copper in digested (mesophilic) sludge and primary (raw) sludge shown in Table 18 are not explained. Measurments of dissolved and particulate trace metals have also been made on a number of Southern California sewage treatment plants. Values for Los Angeles County Sanitation Districts effluent (See Table 19 are very similar to those for digested sludge for Hyperion, probably reflecting the combination of digested sludge centrate with effluent from primary sedimentation tanks in the LACSD system. (Ref. 538.)

It should be noted that the total metal concentrations in the sludge are far higher than those in the effluent. Effluent from the Hyperion 5-mile outfall (See Table 19) shows much larger percentages of dissolved trace metals, reflecting the secondary treatment given to about one third of the total plant flow and separate discharge of digested sludge through the 7-mile outfall. (Ref. 538.)

Physical Transport and Dispersion

The physical bulk density of sludge is between that of fresh water and sea water. Hence, the outfall plume is buoyant and rises as it mixes with the surrounding sea water. The motion of the sludge as it exits from the outfall is influenced by the momentum of the discharge as well as ambient current and density stratification. This first phase typically lasts only a matter of minutes and results in a certain initial dilution and equilibrium height of plume rise. (Ref. 507, 539.)

Larger particles with higher fall velocities settle out of the plume first, as the remainder are carried within the plume and proceed first upward then horizontally. The phenomenon of flocculation may play a part in altering the settling characteristics of the particulates, resulting in more settling nearer the discharge point.

TABLE 18

PARTITION BETWEEN DISSOLVED AND SUSPENDED TRACE METALS IN HYPERION SLUDGE

(All Values in Milligrams per liter)

	Primary (Raw)		Digested-Mesophilic		Digested-Thermophilic		Was - Raw	
Metal	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended	Dissolved	Suspended
Ag Silver	2.40 (a)		3.30 (a)		2.40 (a)		0.30	2.00
Cadmium	0.02	2.48	0.02	2.98	0.02	2.78	0.30	0.77
Chromium	0.09	45.18	0.06	50.26	0.15	52.52	0.70	16.00
Copper	11.00	52.00	11.00	32.00	0.27	36.73	0.50	11.50
Nickel	0.67	10.83	0.36	9.14	0.45	11.05	0.38	1.42
Lead	8.00 (a)		0.50	7.50	0.45	7.55	0.25	2.25
Zinc	1.55	119.45	0.06	77.34	0.20	67.80	0.25	12.75

Source: "Digested Sewage Sludge: Characteristics of a Residual and Modelling for Its Disposal in the Ocean Off Southern California", Faiset, William Karl; EQL Report No. 13, (June 1976).

Note: Dissolved fraction separated from solids by membrane filtration.

(a) Total content.

TABLE 19

PARTITION BETWEEN DISSOLVED AND PARTICULATE TRACE METALS IN TWO EFFLUENTS

(All concentrations in milligrams per liter for solution)
(And milligrams per dry kilogram for particulates)

	LACSD Effluent(1)				Hyperion 5-mile Outfall(2)			
METAL	DISSOLVED	PARTICLES	TOTAL	% SOLUBLE	DISSOLVED	PARTICLES	TOTAL	% SOLUBLE
Silver	.0004	120	.010	4.7	.0045	130	.020	25
Cadmium	.0010	65	.022	4.7	.0014	108	.012	12
Cobalt	.001	8	.004	28	.0004	4	.0008	50
Chromium	.032	1700	.61	5.2	.082	1440	.22	36
Copper	.040	1120	1.1	3.6	.026	1500	.18	14
Iron	.067	20000	7.3	9.2	.14	5400	.68	20
Manganese	.030	150	.080	40	.023	108	.033	66
Nickel	.087	220	.16	55	.10	520	.15	65
Lead	.0062	570	.19	3.2	.003	320	.035	10
Zinc	.130	4100	1.4	9.0	.036	2300	.27	14

Source: "Digested Sewage Sludge: Characterization of a Residual and Modelling for Its Disposal in the Ocean Off Southern California", Faisst, William Karl; EQL Report No. 13, (June 1976).

(1) Concentration of particulates larger than 0.45 μ is 325 mg/l.

(2) City of Los Angeles Hyperion Plant particulate concentration is 100 mg/l.

Due to vertical density stratification in the ocean, and the continual mixing of the buoyant discharge with the more dense sea water, the plume terminates its rise and disperses horizontally after reaching a level where its density is the same as that of the local sea water. Based on typical density profiles in the area, it is estimated that the height of rise of the plume discharged through the Hyperion 7-mile outfall is on the order of 100 to 150 feet (30-45 m) above the discharge depth of 300 feet, at which point the average dilution is about 100. (Ref. 539.)

During the two or three winter months in which vertical stratification is weak or non-existant, there is a free exchange of water between deep waters and the surface and the initial dilution is generally greater. (Ref. 504, 505, 506.)

Following the initial phase, the diluted mixture is advected and dispersed by currents and turbulence in the ocean. Solids tend to settle at rates determined by fall velocity (Ref. 539). The major portion of the sludge particles (estimated range from 75-99 percent) do not settle near the outfalls but are transported with the plume and settle out at greater and greater distances, depending upon factors such as particle size, current velocities and direction, and sedimentation processes. (Ref. 539.)

Several investigators have measured the fall velocity of sludge particles in the laboratory. Results differ greatly, due in part to experimental procedure. It is possible only to bracket the range of reported values as 2 or 3×10^{-5} to 10^{-2} cm/sec. More definitive determination of fall velocities is required, since particle settling rates are an important factor in determining sludge particle distribution in the ocean. (Ref. 507.)

Once the sludge particles settle to the bottom, they may be decomposed chemically or biologically, or physically resuspended and redistributed to settle elsewhere on the bottom. Turbidity currents or geologic slumping are the only significant mechanisms which may move sludge particles on the bottom *en masse*.

In order to fully define the fate of the particulates, it is necessary to have detailed knowledge of ocean transport characteristics in the region of interest. In general, such information is lacking; both direct and indirect methods are being developed to estimate fallout patterns and resuspension. (Ref. 539, 506, 505.)

Chemical Considerations

In the municipal discharges from the LA/OMA area, sludge particles contain the greatest fractions of the organic matter, trace metals, and synthetic compounds. Resultant distribution of chemicals in surrounding waters and sediments will depend upon:

- initial constituent concentrations in local municipal sludges (which may also depend on degree of industrial waste pretreatment).

- the extent of loss of chemicals from the sludge particles upon coming into contact with the sea water.

- the deposition pattern of the particles in coastal sediments.

- mobilization of dissolved chemical species from sediments into overlying waters as a result of degradation, chemical conversions, biologically mediated transformations, etc. (Ref. 539.)

Conflicting results have been obtained in studies of mobilization of metals from sludge particles prior to and following deposition. Metal release rates from Hyperion sludge, upon 100:1 dilution with oxic sea water, were as follows: 40 percent of the cadmium and lead were released from the particles in one hour; 25 to 95 percent of all measured metals except copper, chromium, and iron were released after 35 days. (Ref. 539.) However, significantly different degrees of mobilization were measured for LACSD sludges. Using a deposition, resuspension and transport model developed by SCCWRP, it was possible for LACSD to predict surface sediment concentrations of trace metals by assuming the metals were not mobilized following initial dilution in the receiving waters. (Ref. 506.)

Oxidation rates of sludge organic matter will depend upon the concentration of organic matter, (note that a large fraction of the organic matter is refractory), nitrate, and sulfate present in the sludge. With depletion of oxygen, nitrate becomes the dominant oxidizing agent. (Ref. 507.) Organic deposits around outfalls are subject to oxidative degradation, anaerobic decomposition, and sometimes loss associated with sulfide formation. Occasional erosion may also take place. (Ref. 539.)

There is concern that continuation of sludge build-up can possibly lead to formation of organic-metal compounds in the sediments near the discharge point. For example, highly toxic methyl mercury compounds need to be examined. SCCWRP has reported that only a small percentage of the mercury in the Palos Verdes sediments occurs as methyl mercury compounds. (Ref. 539.) No data are available for other LA/OMA discharge areas.

If sludge discharges are terminated and oxic conditions are restored, it appears that trace metal release will depend upon the chemistry of each metal and upon the dominant mechanism involved in holding it in the sediment. In a sulfide-rich environment, cadmium, lead, copper, silver, mercury, nickel, and zinc metal ions are expected to precipitate as sulfides. Oxidizing conditions may bring about their release by eliminating the sulfide. However, carbonate precipitates of lead and cadmium may replace the sulfides, at least during a transition stage. Chromium, selenium, and arsenic may be more tightly held in the sediments upon restoration of oxidizing conditions, or not affected at all. The evaluation of risk is a matter of rate of the transition from anoxic to oxic conditions. A quantitative picture is not yet possible. (Ref. 539).

POTENTIAL BIOLOGICAL RESPONSES

Municipal sludge discharges contain components that can be expected to produce positive and/or adverse effects depending upon the concentration of each component and the timing and means of sludge discharge. The physiological response in the marine organisms is generally a function of several factors such as the species involved, community structure, and maturity of the organism. This section discusses effects of specific pollutants on the marine ecosystem to provide background information for consideration of effects which have been reported in the Southern California Bight.

Concepts and Principles

The introduction of a chemical compound or a change in the physical environment may affect a natural marine ecosystem in many ways. In coastal waters that have been undisturbed for long periods of time, the ecosystem has adjusted to the existing steady state condition. Usually the system is productive, species are diverse, the biomass is high or low depending on nutrient availability, and the flow of energy is comparatively efficient. The addition of sludge to such a system might:

- increase the input of organic matter and nutrients which might stimulate growth of species, some of which may be undesirable;
- create intolerable physical extremes for some organisms;
- kill or reduce the success of individual organisms;
- eliminate species by adding a toxic material or making essential elements (such as sunlight) unavailable;
- interfere with the flow of energy from species to species, as by a chemical that interferes with feeding behavior;
- reduce species diversity in the system;
- interfere with regenerative recycling by decomposers;
- decrease biomass by reduction of abundant species or disruption of the processes of the ecosystem;
- increase biomass

These responses are examples; additional effects can occur. The specific impacts of pollution can be determined only through long-term study of the affected portion of the ocean and the changes that occur. (Ref. 536.)

Pollutants can be detrimental to fisheries by reducing desired species through direct mortality from toxicity, or by induction of characteristics that make fish unacceptable for commercial or recreational use. Population size may also be reduced by pollutant imposed sublethal stresses that significantly interfere with feeding, movement, reproduction or other essential functions. Pollution can be indirectly deleterious, by contributing to increases in predators or parasites, by reducing food organisms or essential cohorts, or by damaging the efficiency of the ecosystem. (Ref. 536.)

Fisheries production statistics provide useful indications of environmmental quality and the biological health and productivity of marine waters. A continuous high yield of harvestable indigenous fish or shellfish (toxicants and pathogen-free) is one indication that water quality is satisfactory and that environmental conditions are favorable for the biological community. (Ref. 536.)

The general requirements for water quality relative to a successful fishery include:

- favorable, not merely tolerable, uncontaminated environmental conditions at every location occupied during the life history of each species;
- freedom from toxic or tainting contamination, including substances which can be bioaccumulated to unacceptable levels;
- absence of sublethal deleterious conditions which reduce survival and reproductive processes;
- water quality sufficient to maintain the health of the other biological systems which supports useful species;
- absence of environmental conditions which are exceptionally favorable to parasites, predators, and competitors of useful species. (Ref. 536.)

Community development is affected by the timing and dispersion of sludge discharge. Higher successional stages (more mature ecosystems) are reached both when discharge is less frequent and with increasing distance form the source. Opportunists with short life cycles and rapid reproduction and dispersion are favored in unpredictable and disturbed environments. Also, except at those outfalls where toxicants are in lethal concentrations, as in continuous discharges in stable environments, toxicants act discontinuously through time, due, for example, to water mass instabilities and life-cycle changes in species sensitivities.

Evaluation of the effects of pollution or of other environmental changes on the ecosystem involves studies of biological production, species diversity, energy flow, and cycling of materials. The process may be complicated by massive imports and exports at any one site. Although pathways of energy flow and efficiencies are not yet completely understood, they offer a potentially unifying approach to these problems. (Ref. 536.)

Adverse biological responses to pollutants can be classified according to broadly defined types of effect:

Acute: Lethal response or severe damage to organism(s) resulting from short-term exposure to the toxicant(s). Ninety-six hours has been established as the generally accepted exposure time for bioassays determining acute toxicity.

Chronic: Lethal response or debilitating damage to an organism(s) resulting from prolonged exposure to the toxicant(s). Exposure time may be several days, weeks, months, or even years.

Inhibitory: Nonlethal response involving blockage or retardation of physiological processes (such as behavior, reproduction, enzyme activity or energy flow) resulting form exposure to the toxicant(s).

Chronic and inhibitory responses are difficult to observe and quantify, especially in the marine environment. Such responses are usually small in magnitude; difficult to measure amongst the normal background variations found in natural systems; difficult to trace because of the complexity of the system that provides for mitigating and synergistic factors; and require that organisms be studied for several generations. This can mean a several year study for many species of fish. It is not surprising, therefore, that the effects of long term exposure to most chemicals, singly or in combination, in the marine environment are generally unknown. (Ref. 564, 536.) Because of the current gaps in knowledge, the existence and significance of chronic and inhibitory effects in coastal waters are subject to a great deal of uncertainty and much discussion.

Many times statements are made that no effect has been measured. The validity of such statements depends on the specific objectives and manner of conduct of the study in question. Since many of the concerns associated with disposal are sublethal, long-term in nature, and difficult to detect, studies directed to other more detectable concerns may not always provide the basis for an absolute determination of "no effect".

Methods for Characterizing the Effects of Pollution

A number of chemical and biological indicators have been used to identify altered and degraded environmental conditions but the community of animals living in marine sediments probably gives the best indication of conditions. The adult benthic infauna stay in the same relative location, have short life cycles, and respond rapidly to changes that many otherwise be undetectable. (Ref. 542.)

Indicator Organisms: Presence of the polychaete Capitella capitata in the benthic infauna has been demonstrated to indicate marine areas polluted with wastes of biological origin. Other polychaetes such as Schistomeringos longicornis (formerly known as Dorvillea articulata and Stauronereis rudolphi) have been considered indicative of semi-polluted zones. Still other polychaetes are considered to characterize natural, unaffected areas. (Ref. 539.)

Studies with Capitella capitata have more precisely defined its role as an opportunistic species. Because of its tolerance to adverse conditions, Capitella can exist where other animals cannot. Wherever conditions improve, Capitella disappears. Presumably it is eaten by carnivores which have settled in the area. The use of Capitella as an indicator has not been universally accepted. Some workers cite the occurrence of large numbers of Capitella in estuaries far from any source of pollution. However, in this envirommment Capitella is again proving to be opportunistic because it can withstand the estuary's fluctuating salinities. (Ref. 539.) Large Capitella populations have also appeared after marine sewer construction, but before initiation of waste discharge (Ref. 554).

Capitella does not normally occur in large numbers in an offshore natural environment. However, Capitella has been found within some of the canyons of Southern California which are believed, under certain conditions, to represent an organically stressed environmment. Plant debris transported down coast with the currents are trapped and are accumulated in the canyons, producing a type of natural biological pollution. Later this material may slough off and move down the canyon, and the process may be repeated. For example, over 14,000 specimens of Capitella were taken from one 0.5 sq. meter sample in La Jolla Canyon which is located far from any man-made source of pollution. The substrate at this station contained a considerable quantity of plant debris which presumably had been trapped in the canyon. (Ref. 539.)

The presence of Capitella capitata near an offshore sewer outfall is usually indicative of a stressed environment. Two years following the commencement of operations at Point Loma, Capitella was found near the outfall terminus, a location where it was previously unknown. Further evidence for the validity of Capitella as an indicator species arise from comparisons of biological conditions during and after closure of the old Orange County sewer line. Near the outfall, Capitella decreased from 22 to 13 percent of the total number of polychaete specimens soon after closure of the old pipe. (Ref. 539.)

The second species of polychaete, Schistomeringos longicornis, has been used to some extent in Southern California and Europe. In Los Angeles Harbor this species was generally found in areas partially affected by pollution; in offshore waters it is often found with Capitella. In Los Angeles Harbor, if environmmental conditions have deteriorated too far, then Stauronereis will disappear, leaving Capitella. (Ref. 539.)

Other organisms such as foraminifera, clams and ostracods have been put to limited use as indicator species. The decrease or absence of echinoderm species has been cited as indicative of adverse conditions. Certain intertidal algae, such as articulated corallines, have been suggested to indicate domestic pollution or trampling impacts. (Ref. 539.)

In summary, the concept of indicator organisms is useful in assessing environmental conditions, particularly in monitoring programs (Ref. 539). However, total dependence on these species is totally unwarranted, and other measures of community structure and function must be made -- parameters such as abundance, biomass, diversity, trophic structure, and so on.

Infaunal Trophic Index: After studying a number of methods, the Southern California Coastal Water Research Project has concluded that the majority of alterations in infaunal communities can be understood by examining feeding strategies of community members. Two basic feeding strategies (1) feeding on suspended material and (2) feeding on deposited material were found to be of interest because changes in dominance of organisms employing these strategies provides an indication of changes in the amount of particulate organic material present in the benthic environment. (Ref. 542.)

Using collective knowledge gained in many studies, SCCWRP has grouped organisms into four species groups based upon common feeding characteristics:

- Group I contains 19 species representing seven taxa and is dominated by the brittlestar Amphiodia urtica. Species in this group feed by capturing suspended particles that drift into their mucous traps or filtration systems.

- Group II contains organisms that feed both on suspended particles and surface detritus. They are included together because of similar responses to slight enhancements of the particulate load of near-bottom water. Representative members of this group are ostracods of the genus Euphilomedes and the polychaetes Tharyx spp. and Mediomastus spp.

- Group III is dominated by surface deposit feeders and contains four species--three molluscs and one polychaete. The group is dominated by the clam Parvilucina tenuisculpta.

- Group IV contains species that have most often been called indicators of marine pollution. The majority are small marine worms (polychaetes and oligochaetes) which are subsurface deposit feeders. (Ref. 542.)

An index formula is used to generate numerical values that indicate the trophic composition of soft-bottom benthic infaunal communities. Index numbers range from 0 to 100, with low numbers reflecting a community dominated by subsurface deposit-feeding organisms and high values indicating a community dominated by organisms that feed on material in the water column. (Ref. 542.)

The Infaunal Trophic Index is not a pollution index and is subject to limitations in application. It does not intentionally measure the effects of toxic pollutants upon the infauna. At the present time it is applicable only to soft bottom areas and subject to depth limitations although studies are under way to expand its application. (Ref. 542). The California Department of Fish and Game has expressed concern that until the development of the Index is published in a refereed journal of wide circulation and has withstood ensuing critique and refinement, it should be used cautiously as a tool for evaluating surveys and for defining the impacts of municipal and industrial waste discharge to the Southern California Bight. (Ref. 542 and 543.)

Potential Positive Responses to Pollution

Organic matter (dissolved and solid) in municipal discharges can be a food source for marine organisms. Generally marine biologists believe that food in the ocean is limiting for most marine organisms. Addition of organic matter should result in an increase of those marine organisms capable of utilizing this source. (Ref. 564.)

The growth of phytoplankton may be stimulated by the addition of dissolved nutrients (Ref. 539). Increases in phytoplankton growth can be expected to result in more zooplankton and their predators, and eventually more abundant organisms higher in the food web such as fish (Ref. 564).

Suspension feeders such as zooplankton and bivalves also extract nutrients from the water column through direct utilization of particulates. Large particles are physically filtered by the animals. Smaller particles may be sieved onto or adsorbed by mucous nets secreted (and consumed) by the organism. Some suspension feeders consume all the material they catch, expelling the inedible portion with the waste products of the edible fraction. Other organisms "sort" the edible from the inedible before ingestion, expelling the inedible as pseudofeces. (Ref. 538.)

Increased abundance and biomass of benthic and demersal communities may also result from deposition of organic matter from municipal discharges on the ocean bottom. The organic matter may be utilized directly as a food source, or indirectly, by providing nutrition to organisms at a lower trophic level.

There are potentials for managing sludge additions to coastal ecosystems in ways that benefit human uses. These are as yet poorly understood, and efforts to utilize nutrients and other possible resources are primitive. Such possibilities merit vigorous exploration and, eventually, careful application. (Ref. 536.)

In considering increased abundance and biomass, one must consider the species affected, the desirability of these species, and the ecological importance of such species. Undesirable substances (e.g., trace metals and trace organics) associated with the organic particles may contribute to physiological responses in the organisms which could offset positive effects of increased biomass and abundance. Increased abundance and biomass may also be accompanied by depressed species diversity. In such circumstances, links in the ecological system may be eliminated and thus interfere with energy flow and transformation in the system.

Potential Adverse Responses to Pollution

Adverse effects include alteration of physical habitat and changes in marine flora and fauna. The exact nature of the response is site specific.

Habitat Alteration: The physical condition of the ocean bottom near the terminus of outfalls can be altered by the deposition of organic particles. Changes in chemical composition resulting from the buildup of organics include depletion of oxygen and production of hydrogen sulfide. Since the nature of the habitat (e.g., silty, sandy, rocky) often dictates the composition of the community, physical and chemical alteration of the botton can be expected to modify community structure. (Ref. 564.)

Sludge particles in the water column can alter the depth to which a particular wave length of light will penetrate. The growth of marine plants is dependent on light and different species may flourish best in one area of the spectrum. (Ref. 564.)

Changes in Marine Life: In addition to organic matter, sludge contains varying amounts of toxicants such as trace metals and chlorinated hydrocarbons. Obvious concern exists regarding potential lethal effects resulting from exposure to such substances.

Mortality is not necessarily the only response to toxicants. Continued exposure to sublethal concentrations can lower viability, reduce longevity, and slow the growth rate of individuals, and ultimately limit the reproductive potential of populations. For many marine organisms, larger females produce more eggs. A toxic substance that reduces growth thus indirectly lowers the reproductive potential of that individual and its population. Toxicants may also make individuals more susceptible to predation or disease, and could alter normal behavior and distribution patterns. (Ref. 564.).

Phytoplankton concentrate trace metals and chlorinated hydrocarbons from sea water. Zooplankton can uptake pollutants directly from the water. Consequently, a concentrated source of toxicants may be provided to organisms higher in the food web. (Ref. 502.)

Increases in biomass and productivity, as measured by phytoplankton standing crop, may not always occur in the vicinity of sewage outfalls. Some comparisons of chlorophyll a concentrations (a measure of phytoplankton biomass) between control areas and outfall areas have shown enhancement. The amount of sewage discharged, the depth of the discharge, strength and depth of the thermocline, and prevalence of local upwelling may interact to supply or limit nutrients that phytoplankton need to proliferate. (Ref. 504.)

Enhanced growth of phytoplankton and macroalgae may be diminished by the discharge of toxic compounds or by the physical presence of sludge particulates (which interfere with light transmittance). This in turn depresses animal growth. (Ref. 504, 539, 564, 506.) Because of biomagnification, it is possible that marine birds and mammals that occupy the higher trophic levels could acquire body burdens of toxicants that are either lethal or that have significant sublethal effects, even though concentrations of these substances in the water remain extremely low. (Ref. 536.)

It cannot be assumed that there is concentration of mutagenic or teratogenic pollutants that causes no effect on marine wildlife species. It is unlikely that sludge discharges result in widespread acute lethal effects to adult organisms since concentrations of these toxic substances are soon diluted by 150 fold after discharge. The juvenile stages may be more affected since, in general, these stages are more vulnerable. (Ref. 564.)

Sublethal effects, while seemingly insignificant, are added to effects from other sources (e.g., power plants, air pollution, fishing mortality and surface runoff), and thus can be expected to compound reproductive burdens on marine organisms. (Ref. 564.)

- Trace Metals

  Laboratory studies indicate that elevated levels of trace metals in the diet and sea water adversely affect marine organisms and their eggs, embryos and larvae. (Ref. 564.)

  Cadmium has marked acute and chronic effects and may act synergistically with other metals. Trace amounts have been shown to lower the reproductive potential of organisms. (Ref. 564). Some studies indicate cadmium is concentrated by marine organisms, particularly molluscs. A concentration factor of 1000 has been reported for cadmium in fish muscle. There is concern about the comparatively unknown effects of cadmium on the marine ecosystem and implications for human health. (Ref. 536.)

  On the other hand, SCCWRP reports that concentrations of most trace metals decrease with increase in presumed trophic level. Although elevated concentrations of metals were observed in invertebrates at lower trophic levels, SCCWRP did not find that this contamination was passed up the food web to fishes in higher trophic levels. At Palos Verdes metals concentrations in high-level predatory fish were considerably less than concentrations in lower-level infaunal and suspension-feeding organisms.. Of ten metals examined, mercury was the single exception. (Ref. 556.) Such studies of structured and unstructured food webs (using Cs/K ratios) and analyses for pollutant bioaccumulation and biomagnification are a useful approach to assessing potential impacts on the biota and on seafood resources. To date a limited number of ecosystems have been studied. Mechanisms governing bioaccumulation and biomagnification are poorly understood: a number of phenomena, such as antagonism, synergism and metal speciation are occurring. Caution should therefore be exercised in interpretation of such data.

Data on trace metals in marine birds indicate local patterns of coastal contamination. Trace metal analyses of several species of petrels, strictly pelagic in distributon, and of coastal fish eating species such as the brown pelican (Pelecanus occidentalis) and the common tern (Sterna hirundo) have confirmed this conclusion. Cadmium levels in tissues of ashy petrel (Oceanodroma homochroa) from coastal waters of California were approximately twice as high as in tissues of Wilsons petrel (Oceanites oceanicus) obtained in Antarctica. (Ref. 536.) Whether this contamination is related to marine discharge is now known. Mercury has also been shown to accumulate in birds via the food web. (Ref. 502).

Very little is known about effects of metals on marine mammals. Mercury, selenium, cadmium and bromine may play some role in premature births of California sea lions. (Ref. 502.)

Trace Organics

Chlorinated hydrocarbon compounds such as DDT are proven toxins. These and other persistent insecticides have been found in marine organisms and have been shown to be passed through the food web. (Ref. 536.)

DDT and PCBs interact synergistically in that a mixture of these substances in the same concentrations inhibited diatom growth substantially more than did either DDT or PCBs separately. DDT and PCBs occurring separately reduce cell division rate of phytoplankton and thereby indirectly reduce total phytosynthetic carbon fixation. Photosynthetic capacity of individual phytoplankton cells, however, is not affected. As in the case with many other toxins, phytoplankton show differential sensitivities to PCBs, which can alter the species composition of natural populations. At 1 ppb no effects were measured on smaller diatoms and flagellates, whereas the growth of larger diatoms and dinoflagellates was suppressed. Elimination of larger cells could have a significant effect on the food chain since cell size is an important factor in determininbg size and type of planktonic herbivore and indirectly the length of the food chain. (Ref. 506).

PCBs and chlorinated benzenes have been shown to damage liver cells. (Ref. 564). Changes in Dover sole can include increased size and irregularity of fatty vacuoles, structural disarray, increased fibrotic tissue, and more numerous melanin-macrophage centers.

One class of chlorinated benzenes (p-DCB) can act as a mitotic poison, causing disorders of cell division that result in abnormal multinucleate cells. In a study in which brine shrimp (Artemia salina) were exposed to 10 ppm 1, 3, 5 - trichlorobenzene for 24 hours, the overall reproductive performance of the adults was reduced by a factor of 10. Chlorobenzene accumulation in animal and plant tissues may cause physiological difficulties that could lead to a shortened life span. Alteration of normal reproductive or developmental patterns might also be expected, especially if dichlorobenzenes affect mitotic and meiotic mechanisms. (Ref. 537.) Unfortunately, very little research has been conducted on reproductive inhibition of marine organisms resulting from chronic exposure to chlorinated benzene compounds (Ref. 513).

Marine birds and mammals concentrate DDT, PCBs and other persistent trace organics in their body tissues (particulary those rich in lipids) from their food. Chlorinated hydrocarbons can also affect bird populations by causing reproductive failure in the form of thin egg shells. Effects of DDT and PCB on marine mammals may be to induce reproductive failure. (Ref. 502.)

REPORTED RESPONSES IN SOUTHERN CALIFORNIA

Municipal discharges to the Southern California Bight have occurred for many years. Study of the effects of these discharges intensified with the formation in 1969 of the Southern California Coastal Water Research Project (SCCWRP) by Joint Powers Agreement among Ventura County, Cities of San Diego and Los Angeles, and the County Sanitation Districts of Los Angeles and Orange Counties. Each of the LA/OMA operating agencies conducts monitoring programs directed towards determination of conditions in the outfall areas. These efforts provide, in large measure, the data and information on reported responses of the Southern California Bight to sludge discharge.

Water Column

Studies of sewage waste disposal in Southern California marine waters have generally focused upon the more dramatic effects on benthic communities around outfalls and have usually neglected planktonic studies. Southern California municipal discharges do not seriously deplete oxygen in receiving waters but can add plant nutrients and toxicants. Possible effects upon the planktonic community such as from zooplankton ingesting pollutant-laden particles or from interference with chemoreceptors used to find food have not been studied. (Ref. 507.) Nanoplankton (cells less than 20 microns in diameter), the most important and quantitatively stable class of phytoplankton offshore and nearshore, have not been studied in the Bight waters (Ref. 504). Although detailed knowledge is limited, some effects of waste discharge upon water column organisms have been identified.

In Santa Monica Bay during the period from 1957 through 1961, effluent from the Hyperion Treatment Plant was discharged through a shallow 1-mile outfall. Highest plankton standing crops (zooplankton and phytoplankton combined) occurred near the 1-mile outfall. When some of the discharge volume was transferred to the 5-mile (60-meters deep) outfall in 1960, the area of higher plankton concentration moved offshore. After 1962, when all wastewater was discharged through the 5-mile outfall, plankton decreased generally throughout the Bay. This decreased productivity may be the result of limited transfer of nutrients from the deep outfalls to the euphotic zone where phytoplankton live. (Ref. 504.)

The potential for enhancement of red tide phytoplankton blooms by nutrients from sewage effluent has been an item of concern. Although it is unlikely that sewage effluent triggers red tide formation (Ref. 504), it could possibly enhance or prolong blooms. (Ref. 506.)

Between 1970 and early 1975, several different investigators observed moderate eutrophication around the Los Angeles County outfall area, occasionally even when the water column appeared to be relatively well stratified. However, periods of greatest enhancement generally coincided with intrusion of the waste field into surface waters. Evidence for eutrophication included elevated ammonium concentrations, high phytoplankton standing stocks, and high rates of primary production and nitrogen uptake. Magnitude of this enhancement was similar to that which characterizes natural upwelling areas along the Southern California Coast. (Ref. 506.)

There is no indication that enrichment of the Los Angeles County outfall area has stimulated dominance of unusual species. However, this question is not well studied and deserves further attention. Euphotic zone ammonia concentrations near the outfall have been found to be high near the surface, a condition which implies that input of nutrients is too massive for phytoplankton uptake. (Ref. 506.)

The effect of sewage effluent on phytoplankton growth is complicated by the presence of certain inhibitory substances. Bioassays of the outfall receiving water in 1971 and 1972 showed that at times it stimulated and at other times inhibited the growth of test algae (different test species were used in these cases, however). Other experiments in 1972 measured the effect of diluted primary-treated Los Angeles County and Hyperion (Los Angeles City) sewage effluent on the carbon and nitrogen productivity of natural populations. Los Angeles County effluent was diluted with 23, 230, and 2300 parts of sea water. Hyperion effluent was diluted with 11, 14, and 1145 parts sea water. At the highest effluent concentrations, both carbon uptake (photosynthesis) and ammonium uptake was inhibited. At the intermediate dilutions (ammonium content of 10 μg-at^{-1}) only ammonium uptake was inhibited. This inhibition was due to some quality other than the high ammonium concentration since ammonium added singly had no such inhibitory effect. Inhibition of nitrate uptake was observed in the maximum dilutions of both effluents (ammonium content only 1 μg-at^{-1}). This latter effect is due to the preferential uptake of ammonium above an ammonium concentration of about 0.5-1.0 μg-at^{-1}. On the basis of these results and the measured ammonium concentrations in the LACSD outfall region it is apparent that phytoplankton are at times exposed to inhibitory concentrations of effluent. (Ref. 506.)

The City of Los Angeles has conducted a phyto-zooplankton survey in the vicinity of the outfall system over a 14 year period. Comparison of plankton fluctuations observed over this time period in the Santa Monica Bay with variations in the California Current shows that fluctuations in phyto-zooplankton abundance in Santa Monica Bay track the California Current curve almost perfectly. This strongly implies that variations that have occurred in Santa Monica Bay are caused by large scale climatic events that affect the entire California Current system. Thus, the University Task Force concluded that the Hyperion outfall system does not appear to cause variations in zooplankton abundance. This is consistent with the observations of the University Task Force regarding a lack of change in primary productivity or phytoplankton standing crop. (Ref. 539.)

It is likely that outfall effects on primary productivity are extremely variable, depending upon the amount of advection and diffusion of the sewage field into the euphotic zone, the rate at which the phytoplankton can respond to toxics or increased nutrient input, the current pattern and advective transport of the phytoplankton and effluent away from the area, and the decay rates of phytoplankton blooms. (Ref. 506.)

Further investigation of phytoplankton responses to sewage effluent, particularly with respect to nutrient uptake parameters, is warranted. Further studies would be valuable, particularly in light of changes in sewage effluent quality since 1973 and projected future additional secondary treatment. Since phytoplankton can provide a very sensitive and rapid response to changes in their environment, they are also ideally suited as bioassay organisms. (Ref. 506.)

Pelagic fishes are only partially assessed in monitoring programs. By definition most pelagic species are highly mobile, belong to the Bight or the California Current system as a whole, and have only limited relevance for the waste discharge effects. Pelagic species are also individually ephemeral, highly seasonal, and subject to aperiodic changes in oceanographic conditions. (Ref. 506.)

There have been occasional undocumented (for the most part) charges that waste discharge has caused a substantial decline in all fish populations in Southern California. Others attribute these same facts to natural cycles. Localized monitoring provides little insight into the validity of such assertions as these declines have been documented over far greater reaches than just the areas to which LA/OMA agencies discharge. California Cooperative Oceanic Fisheries Investigations (CALCOFI) and State Fish and Game records can be used to describe trends. A summary discussion of Bight-wide possibilities, including relationships to outfalls, is contained in SCCWRP reports (Ref. 501, 509, and 508). Most often the controversy surrounding the cause of such reductions involves overfishing versus natural events which may have altered the basic nature of the pelagic realm. Pollution is also mentioned as a possible cause of major declines, although atmospheric lead pollution and DDT from sewage are both widespread enough to be suspect. In both cases, the timing, magnitude, and location of these pollutant additions do not correlate well with observed declines. (Ref. 506.)

A major decline of sardine stocks in the late 1940s may be a function of a natural cycle coupled with overfishing, but DDT has been implicated (Ref. 504). Following the decline of the local sardine population, its ecological role was filled by the anchovy. Evidently this sort of replacement of one species by another has occurred several times over the past 2,000 years. (Ref. 506.)

Although sportfish and commercial fish landings near LA/OMA discharge sites are higher than elsewhere along the coast, there is no conclusive evidence that landings or catch per unit effort are connected with solids emission (Ref. 540.) Some of the fish landed from catch areas near Palos Verdes still contain unsafe levels of DDT, but no attempt has been made to regulate fishing based upon this information. Large schools of anchovy are occasionally observed near discharges off Palos Verdes and in Santa Monica Bay and observers speculate that they may be feeding on sewage particulates. (Ref. 540.)

In summary, pelagic organisms are best monitored by large scale efforts such as that of CALCOFI. Studies are essential to a fuller understanding of man's impact on the marine ecosystem. The importance of this effort (large scale monitoring) is related to the broad range and mobility of the pelagic community as well as its resilience. The effects of natural and/or outfall-related events cannot be understood without the perspective provided by such a program. (Ref. 506.)

Waste discharge has been implicated in the demise of the kelp forests off the Palos Verdes Peninsula. Abundant in the 1930s, kelp beds offshore of Palos Verdes began a continuous decline in size, and the rate of decline appeared to steepen in the mid-1940s. Kelp was entirely absent between 1968 and 1971. Primarily as a result of a series of transplant and culturing efforts, nearly 593 acres of giant kelp (Macrocystis sp.) are now thriving in scattered beds along the Peninsula (1980 data from California Department of Fish and Game). It should be noted that not all beds along the Peninsula are the result of transplants. The bed at Bluff Cove has recruited naturally and its canopy was first documented in July 1975. Other scattered plants and small beds have also been documented. (Ref. 504.)

While most kelp beds undergo annual and long term fluctuation in size and density, causative factors for the disappearance of the kelp beds include proliferation of grazing invertebrates, absorption of light by particulate matter, and siltation of rocky substrates. Local extinction of the sea otter in the last century and reduction in the numbers of other sea urchin predators, such as sheephead (Pimelometopon pulchrum) may also be implicated in longer-term instabilities of kelp population.

Wastewater discharge began at Whites Point in shallow water (27 meters) in 1937 and was diverted to deeper waters (60 meters) in 1954. Settleable solids discharge has decreased since 1970, except for one excessively high level period in 1976. Current concentrations (1979) are approximately 0.9 milliliters per liter. Suspended solids discharge also declined beginning in 1976. Comparison of kelp canopy area changes indicates that these changes may have had a beneficial effect upon kelp resurgence. Two causative factors - light absorption and siltation of rocky substrates - can result from excessive discharge of solids. Another change in the discharge at Whites Point over the past six and one-half years is the dramatic decline in DDT concentrations as a result of source control in 1970. (Ref. 504.)

SCCWRP has studied the effects of chromium upon polychaete reproduction and sea urchin embryo development, and the effects of chlorinated benzenes upon sea urchin embryos. High concentrations of chromium (well above that of sea water) were shown to adversely affect polychaete reproduction and development of sea urchin embryos. Studies involving chlorinated benzenes showed abnormal development of sea urchin embryos. However, no study has been made involving concentrations found in effluents or sediments. (Ref. 557.)

Data on the effects of such potential toxicants on marine life, especially in the water column, are sparse. Bioaccumulation and bioassay studies are needed, on field and laboratory populations in control areas and near discharge sites, at all life stages and in different trophic groups.

Benthos

Infaunal benthic organisms are relatively immobile and as such must experience the physical and chemical conditions of their environment. Benthic organisms are subject to fallout of materials added to or generated in overlying waters. They may concentrate and or transform chemicals and other anthropogenic materials from such particulate flux.

Increased abundance and decreased species diversity are the major responses of Southern California benthic infauna to municipal discharges. Magnitude of these responses generally increases with proximity to the discharge site and with the volume of discharge. In regions most influenced by this "biostimulation" response, abundance can increase ten-fold above background (i.e., to 20,000 to 30,000 animals/sq. meter) and biomass nearly 20-fold (i.e., to 2,000 g/sq. meter). It has been estimated that LA/OMA and other Southern California deep water outfalls directly cause biostimulation over an area of about 100 square km or 3 percent of the mainland shelf. (Ref. 504.)

Within the areas of biostimulation, there are zones of depressed biological activity and species diversity. Hydrogen sulfide levels or low oxygen levels in the sediments may be important factors in this regard. (Ref. 504.)

The community characterized by the brittlestar Amphiodia urtica is one of several which are unable to colonize the discharge sites. Amphiodia is reported to be absent or in low abundance outside of areas obviously impacted by discharges; abnormally low abundances may occur over nearly 7 percent of the mainland shelf. (Ref. 504.) Low abundances have also been observed at organically enriched areas such as Point Conception (Ref. 506).

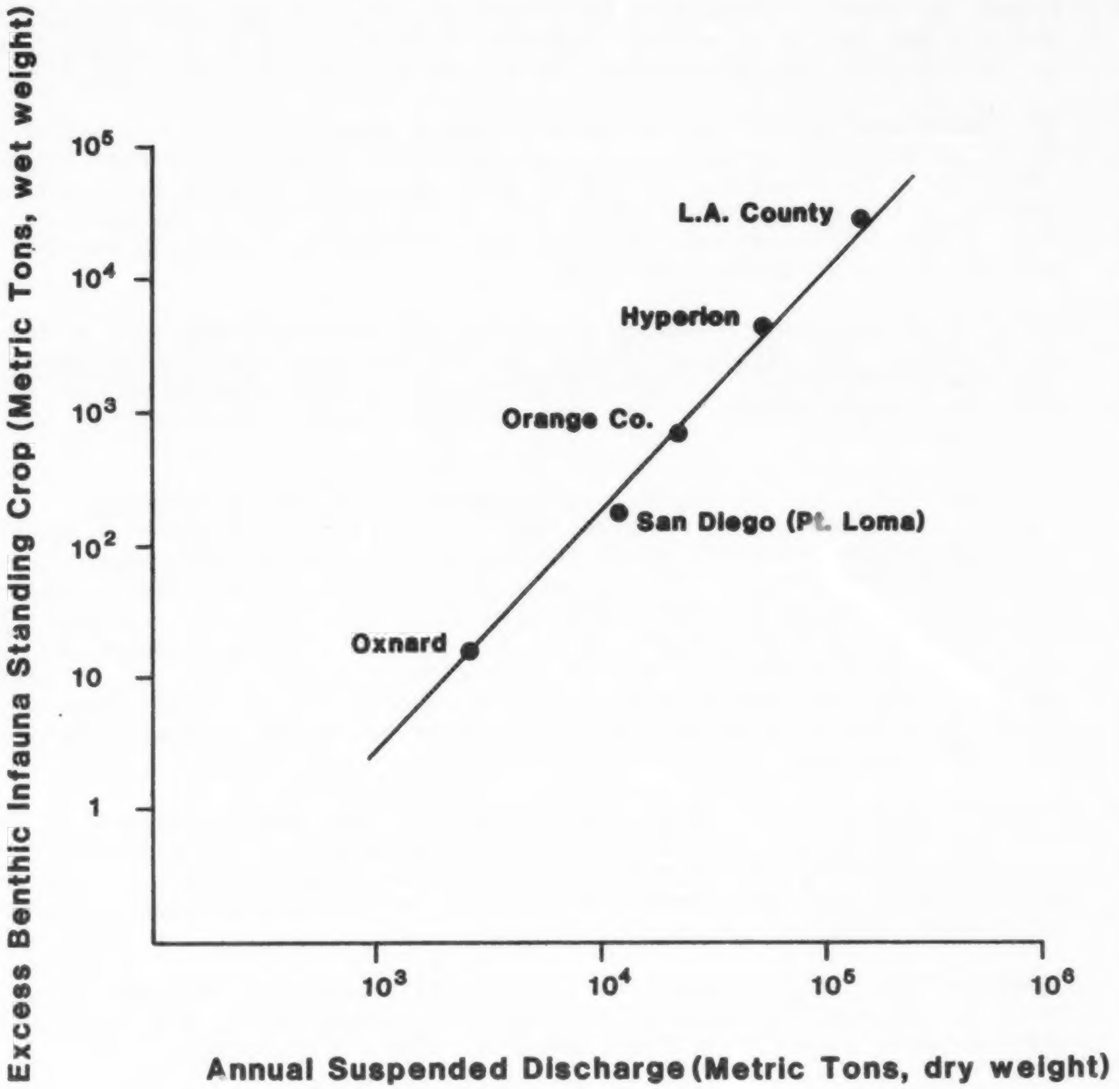
Communities that replace Amphiodia contain indicator organisms such as the polychaetes Capitela capitata and Tharyx sp., and the clam, Parvilucina tenuisculpta. When examined together, the overall abundances of these species produce a consistent, predictable measure of the progression of impacts around outfall sites. (Ref. 504.)

It seems likely that the benthos is responding primarily to discharge of solids. Using data related to the different quality of six major Southern California ocean discharges and simultaneous measurements of corresponding benthic conditions, SCCWRP has developed a relationship between excess benthic standing crop (the amount in excess of what would normally be expected) and suspended solids mass emission rates (See Figure 10). (Ref. 504.) The magnitude of the resultant infaunal biomass can thus be both quantified and predicted. SCCWRP has calculated that approximately 18-19,000 metric tons of bottom organisms are excess above normal standing crops, and can be attributed to sewage particles in the LA/OMA area (Ref. 540).

Increased abundance also appears to be the major and general response of demersal fish and invertebrates to local deep water discharges but the magnitude of increase is generally less than the infauna. Some exceptions to this trend have occurred along the Palos Verdes Peninsula at the Los Angeles County discharge site. (Ref. 504.)

Demersal fishes which account for increased fish abundance near deep water outfalls include speckled sanddabs, English sole, shiner perch, and, on occasion, white croaker, juvenile rockfish, and Dover sole. (Ref. 504.)

Habitat Alteration: Using the results from the 1977 survey of coastal waters at 60-meters depth, SCCWRP has related benthic community feeding patterns (as measured by the infaunal trophic index) to sediment biochemical oxygen demand and volatile solids content. Table 20 summarizes the results of this effort. Figure 11 shows contours of infaunal index values in areas near LA/OMA operating agency outfalls,based upon data available in 1978 (Ref. 545). At infaunal index values of from 60-80, the number of species, biomass, abundance, BOD, and volatile solids increase slightly and the infauna remains dominated by suspension



NOTE: ● = Discharge Site

SOURCE:

"Report on Task 2, Describe Existing Conditions", SCCWRP, September 29, 1977.

INFAUNAL BIOMASS VS SOLIDS DISCHARGE

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 10

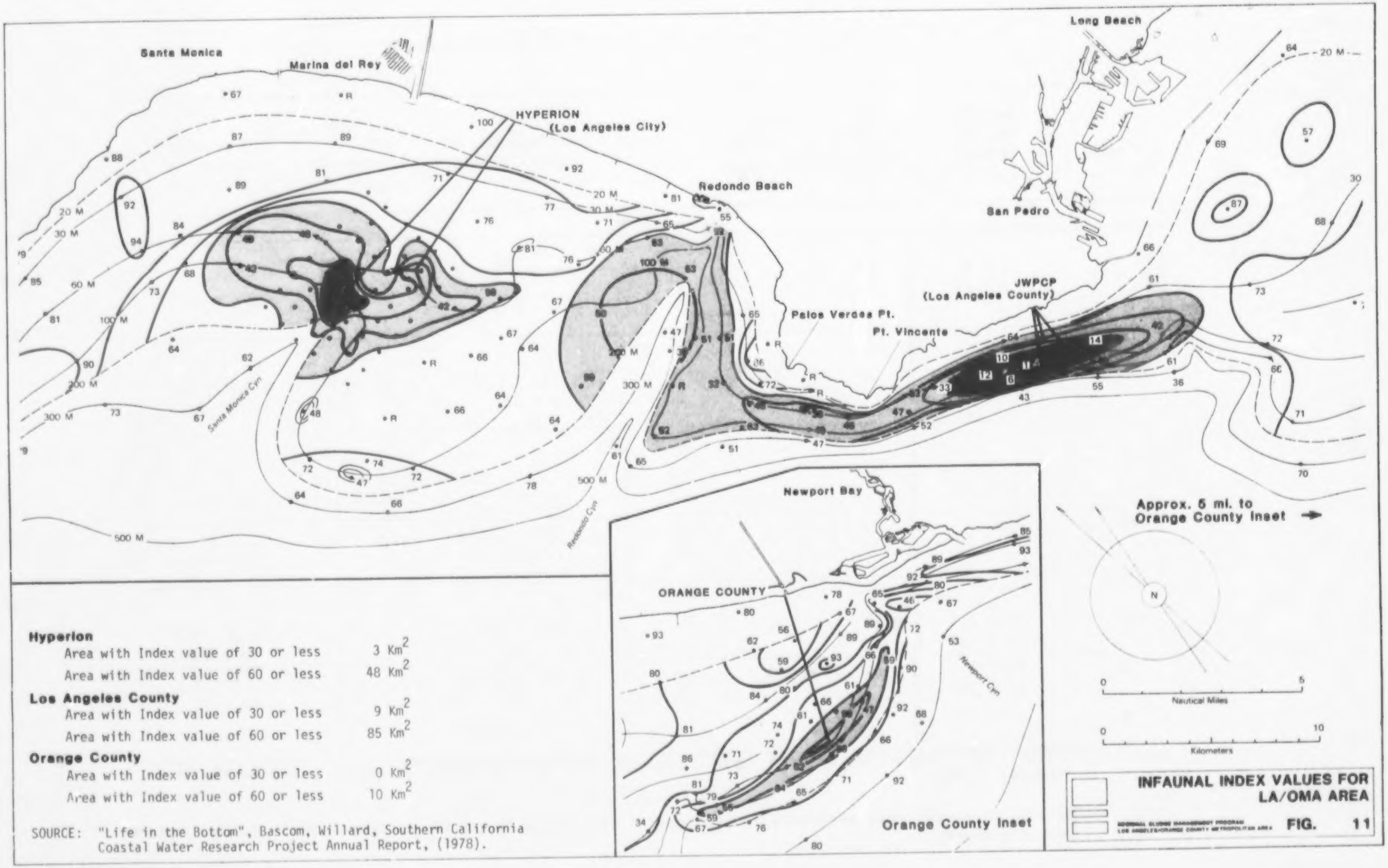
TABLE 20

INFAUNAL INDEX APPLIED TO 60-METER SURVEY RESULTS

	Infaunal Index	Average No. of Species/ 0.1 sq m		Dominant Feeding Strategy of Infauna (% in Group) I, II	III, IV	Average Biomass (g/sq m)	Average No. of Individuals/ sq m	Average BOD of Sediments (mg/dry kg)	% Volatile Solids in Sediments
	100		Suspension Feeders						
Control Areas	90	71 ± 4 (n = 29)		96	4	70 ± 5 (n = 29)	4,230 ± 240 (n = 29)	632 ± 38 (n = 29)	2.8 ± 1 (n = 29)
	80								
	70	77 ± 7.2 (n = 23)		79	21	81.7 ± 9.7 (n = 18)	6,179 ± 720 (n = 23)	870 ± 123 (n = 18)	3.9 ± 0.7 (n = 37)
	60		Surface Feeders						
	50	69 ± 5 (n = 30)		56	44	168 ± 47 (n = 30)	7,725 ± 1,886 (n = 30)	1,188 ± 174 (n = 10)	5.2 ± 1.3 (n = 23)
	40	48 ± 2 (n = 38)		21	79	254 ± 65 (n = 21)	8,935 ± 1,056 (n = 38)	2,421 ± 600 (n = 22)	5.8 ± 0.8 (n = 20)
	30		Subsurface Feeders						
	20	31 ± 2.4 (n = 12)		19	81	623 ± 160 (n = 12)	3,480 ± 763 (n = 12)	12,893 (n = 3)	11.6 ± 4.7 (n = 3)
	10	23 ± 2 (n = 25)		7	93	223 ± 71 (n = 25)	6,401 ± 1,005 (n = 25)	17,021 ± 2,038 (n = 9)	20.6 ± 2.7 (n = 9)
	0								

Source: "Establishing Boundaries Between Normal, Changed, and Degraded Areas", Bascom, Willard, et. al., SCCWRP, (1978).

Note: Only Palos Verdes data were used for Infaunal Index values below 30, as these conditions are seldom seen elsewhere.



Hyperion	
Area with Index value of 30 or less	3 Km^2
Area with Index value of 60 or less	48 Km^2
Los Angeles County	
Area with Index value of 30 or less	9 Km^2
Area with Index value of 60 or less	85 Km^2
Orange County	
Area with Index value of 30 or less	0 Km^2
Area with Index value of 60 or less	10 Km^2

SOURCE: "Life in the Bottom", Bascom, Willard, Southern California Coastal Water Research Project Annual Report, (1978).

INFAUNAL INDEX VALUES FOR LA/OMA AREA

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 11

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feeding organisms. At index values ranging from 45-60 the infauna is dominated by surface-deposit feeding invertebrates. As index values decrease in this range, biomass and abundance continue to increase, but the number of species decreases slightly. BOD and volatile solids have increased until they are about 50 percent greater than control values. At Index values ranging from 30-45, biomass and abundance are nearly double the controls. Surface feeding clams tend to dominate the infaunal communities and the number of species is significantly below the control value. Index values below 30 are found only in regions close to large wastewater outfalls. The infauna are dominated by subsurface-deposit feeding invertebrates. Biomass and abundance begin decreasing and the number of species is less than half that at control sites. (Ref. 544.)

Examination of Figure 11, from SCCWRP's 1978 survey (Ref. 545), shows that municipal outfalls mark the epicenters of depressed infaunal index values, and contours of increasing index values appear to radiate outward from the outfalls. SCCWRP has calculated that 4.6 percent (168 sq km) of the 3,640 sq. km coastal shelf of southern California between 20 and 200 meters depth show index values of 30 to 60, while 12 sq. km have an index range of 0 to 30. (Ref. 544.)

Santa Monica Bay: The spatial distribution of sludge modified areas is difficult to define because of differing responses to various criteria. Table 21 lists sludge affected areas in Santa Monica Bay for several criteria. Size of the impacted area varies, depending upon the basis of measurement. (Ref. 539.) Such variations are likely at each outfall location.

Combining the distributions of known pollution tolerant and sensitive species with the overall contours of the infaunal trophic index, SCCWRP has recently re-estimated the dimensions of altered benthic community structure and has partially separated the impacts from the 7-mile (sludge) and 5-mile (partial secondary effluent) outfalls. The total changed area in Santa Monica Bay is approximately 60 sq. km. Of this total, 6 to 10 sq km of altered benthic community appears to be related to the 5-mile effluent discharge; modification of the remaining 50 to 54 km is attributed to the sludge outfall. (Ref. 559.)

The effects of the 7-mile discharge are first seen and most apparent in Santa Monica Canyon. Enhanced abundances of the "pollution tolerant" species *Capitella capitata* extend downcanyon 4 km from the head of Santa Monica Canyon and upcanyon onto the shelf 1.7 km from the discharge point which is the center of distribution of this species. Large populations of *Capitella* exist elsewhere on the shelf, where the influence of the 7-mile sludge line and 5-mile effluent line overlap. High densities of *Parvilucina teniusculpta* (clam), *Listriolobus pelodes*, (echiuran) and *Euphilomedes carcharodonta* (ostracod) are also centered around the sludge outfall. Sensitive species, predominantly suspension feeding ophiuroids (brittle stars) and amphipods (crustaceans) avoid the outfall area. Macrobenthic abundance is nearly an order of magnitude above background. (Ref. 559.)

TABLE 21

SLUDGE MODIFIED AREAS IN SANTA MONICA BAY ACCORDING TO VARIOUS CRITERIA

Criteria	Area of Modification	
Detectable H_2S (1)	4 km^2	(1.5 mi^2)
PCB (2)	6 km^2	(2.5 mi^2)
Volatile Solids (3)	10 km^2	(4.0 mi^2)
Species Diversity (4)	25 km^2	(9.5 mi^2)
Capitella capitata (5)	35 km^2	(13.5 mi^2)
Infaunal Trophic Index (6)		
Values of 30 or less	3 km^2	
Values of 60 or less	48 km^2	

Source: "Report of the University Task Force to Evaluate Water Quality Effects of Hyperion Sludge Discharge", Koh, Robert, et.al, (May 1977) and "Establishing Boundaries Between Normal, Changed and Degraded Areas" Bascom, Willard, SCCWRP, (1978).

(1) Indicative of organic decay in an oxygen depleted area.
(2) Man-made polychlorinated biphenyls.
(3) Indicative of high organic content.
(4) High value is indicative of a natural area; low value indicates a stressed environment.
(5) Marine polychaetous annelid worm which thrives around sewer outfalls.
(6) Provided by SCCWRP.

Abundance patterns of bottom living fish in Santa Monica Bay have been studied by trawl surveys. In general, the Santa Monica Bay demersal fish populations are consistent with similar areas. However, trawls through the sludge field, at depths of 124 through 183 meters, have shown that fish near the 7-mile sludge line are more abundant and larger than at control sites, although fish populations are slightly less diverse. Trawl-caught invertebrates are also more abundant and less diverse than at reference sites. Dominant fish include Dover sole (*Microstomus pacificus*), white croaker (*Genyonemus lineatus*), slender sole (*Lyopsetta exilis*), and Pacific sanddab (*Citharichthys sordidus*). The most abundant invertebrates are the star *Astropecten verrilli*, the prawn *Sycionia ingentis*, and the sea pen (*Acanthoptilum sp.*). Visual observations of the pipe revealed large numbers of anemones, echinoderms and rockfishes colonizing the pipe and riprap. Thus the sludge outfall area harbors unusually high numbers of fish and macroinvertebrates. (Ref. 559.)

Phytoplankton populations are being stimuated (growth may be several factors above normal) in Santa Monica Bay. However, it appears that this is a response to source(s) other than the 5-mile effluent pipe or the 7-mile sludge line. (Ref. 559.)

Palos Verdes Shelf: Disposal of sewage solids at Whites Point has been in the form of primary effluent suspended solids and centrate return from sludge dewatering in the treatment plant. Multiport diffusers release the wastes at a shelf depth of 60 meters, two miles offshore. Two components of the discharged waste have produced observed problems among the Palos Verdes fauna and flora: particulate flux and trace contaminants. It is difficult to separate the effects attributable to the organic and trace contaminant fractions(whose distributions are often similar).

Maximum biological/physical/chemical impact on the benthos has been observed in the area northwest of the outfall diffusers at a depth of 60 meters. Prevailing subsurface currents to the northwest maximize deposition of particulates of sewage origin in this area, where sediments are rich in organics and chemically bound trace contaminants. Other associated physical/chemical changes, such as generation of hydrogen sulfide, have occurred over a significant portion of the Palos Verdes shelf as a result of high influx of organic matter from the outfall. The overall biological response in areas of greatest impact has been reduction in diversity, enhancement of a few species of detritus feeding polychaete worms (*Capitella capitata*, dorvilleid sp. 1, *Schistomeringos longicornis*), a reduction in molluscs and crustacea, and an absence of echinoderms. (Ref. 506.)

At greater distance from the outfall, where deposition rate of organic matter and trace toxicants have been slower, the enhancement in the standing crop of the small clam *Parvilucina tenuisculpta* (which thrives under conditions of increased food supply, a condition met in the outfall areas) has been observed. Species richness is greater and opportunistic polychaetes are no longer prominent at more distant sites. However, calculated diversity remains depressed. (Ref. 506.)

The foregoing has been the generalized response pattern of the Palos Verdes benthos to waste discharge, as observed before and after the "echiuran period" of the mid 1970s. Benthic activities of *Listriolobus pelodes* (Phylum Echiurida or "spoon worms") are believed to have greatly augmented treatment changes to markedly improve sediment quality and biological community parameters between 1973 and 1977. (Ref. 506.)

Prior to 1973, new sludge digesters and sedimentation tanks were added at JWPCP and refinery thiosulfate disposal was limited. Industrial discharge of DDT to the outfall system was prohibited in 1970, and an industrial waste source control program was initiated during 1972-73. Reductions in mass emission rates of suspended solids and trace contaminants appeare to have been reflected in local sediment quality. Contraction of the areal extent of observed hydrogen sulfide and observable sludge particles and black sediments, reductions in chlorinated hydrocarbon and heavy metal concentrations in surface sediments were observed responses. The population and range of several key pollution-tolerant species such as *Schistomeringos longicornis* diminished as treatment improved. The clam *Parvilucina tenuisculpta*, absent from the most heavily polluted sediments in 1972, has been present throughout the outfallaffected region since January 1973. *Capitella capitata* populations also decreased in size and areal extent, although a resurgence occurred during spring 1973, with a community alteration which affected the entire shelf (and included the echiuran settlement). The population of dorvilleid sp. 1 was decreasing in the outfall area before *Listriolobus* entered. (Ref. 506.)

This benthic response pattern to discharge improvements was greatly modified beginning in spring 1973, by settlement of dense aggregations of the echiuran ("spoon worm") *Listriolobus pelodes*. Initially, a large population developed at an intermediate distance from the outfall, and by 1975 the center of abundance had moved toward the discharge points, where maximum numbers (almost 1500 per sq. meter) and biomass (over 2000 gm per sq. meter) developed. Since 1976 echiuran populations have steadily declined; a single specimen was collected on the shelf in summer 1978 and none in 1979. *Listriolobus* is one of the largest of the infaunal invertebrates collected on the shelf; even small numbers tend to dominate and modify the sediment character and community structure Its burrowing, feeding, and respiratory activities rework and aerate the sediments. A more complex and diverse community developed, and a "*Listriolobus* association" of species was observed across the shelf. The infaunal trophic index rose, and the proportion of subsurface burrowing, deposit feeding organisms was high. Marked improvements in sediment quality paralleled echiuran abundance patterns. Adverse outfall effects were reduced. Substantial improvements in effluent quality attributable to treatment modifications (increased digester capacity, installation of basket centrifuges, polymer addition, and more effective pretreatment) also contributed significantly to improved benthic conditions.

After the Listriolobus population collapsed, reversal of some environmental gains was observed in the sediments in the outfall region (hydrogen sulfide again increased, for example). Pollution-tolerant polychaete species (such as Capitella capitata, Schistomeringos longicornis and dorvilleid sp. 1) replaced the Mediomastus-Tharyx-Mysella-spionid dominated community which thrived after echiuran establishment and during its decline. Diversity decreased. (Ref. 506.)

It appears that the current benthic situation is unstable, and reflects disturbed conditions. This instability is not surprising. In general, communities totally dominated by one species tend to be unstable ecologically; loss of that dominant species is a very significant event. When Listriolobus disappeared, so did its associates; sediment bioturbation and quality declined; unexploited niches became available; and opportunistic species successfully recruited into the area. The rate of physical/chemical/biological alteration is expected to decrease in the near future, irrespective of treatment modifications. A more stable community will develop, whose composition will depend particularly on sediment parameters related to past and improved effluent practices. (Ref. 506.)

There have been brief, selective studies of growth and reproduction on the Palos Verdes shelf. No specific season appears to be most important for reproduction, although recruitment seems to occur more commonly in the first half of the year. Free-swimming larval stages (typical of most marine benthic animals) are available for dispersal and colonization year-around. Opportunistic species (small organisms with high reproductive potential and dispersal abilities) appear to be more abundant near the outfall. The proportion of conservative species (larger animals with lower reproductive effort and dispersal capacity) increases with distance from the diffusers. (Ref. 506.)

Quantitative information is unavailable on breeding types, brood sizes, larval development rates and settlement success on the shelf, and on the effects of effluent quality on these reproductive parameters. An example of discharge-induced effects on growth and reproduction is the halo distribution of Parvilucina. This bivalve is numerically enhanced at intermediate distances from the outfall and reduced in numbers, although larger in size, near the outfall. (Ref. 506.)

Analysis of data gathered from the SCCWRP "60-Meter Survey" has shown the Palos Verdes fauna to be distinct in several ways: fewer species, fewer crustaceans, no echinoderms, enhanced annelid and mollusc abundance and biomass and low diversity (evenness and richness). Community structure differed from that near the Hyperion and Orange County outfall areas. Results of weighted multiple discriminant analysis suggest that reduction of high levels of five parameters -- organic nitrogen, chromium, DDT, lead, and BOD, in Palos Verdes shelf sediments should contribute toward development of a faunal community more typical of the Southern California shelf. (Ref. 506.)

In summary, solids disposal has had detrimental consequences in the benthic environment of the upper shelf. Influx of high organic loads has produced benthic communities dominated by small to large numbers of a few species of tolerant worms. Moderate additions of organic material has enhanced standing crop and abundance, and has led to reduced diversity and to community structural and functional changes such as enhancement of surface or subsurface deposit feeders. Among the sediment characteristics associated with increased organic loading are hydrogen sulfide or hypoxic conditions, changes in grain size, and increases in reduction potential. Once these conditions become established, they can persist for an extended period: many of the organic forms present are not easily oxidized. Trace contaminants usually reach sediments via attachment to the particulates.

The inshore rocky subtidal environmment off Palos Verdes has been altered by waste discharge in three ways:

(1) Increased turbidity due to the presence of suspended particulates in the water column.

(2) The burial of hard substrate following the sedimentation of water column particulates in the form of a fine organic floc.

(3) Increased levels of potentially toxic trace constituents in the sediments and floc.

Increased turbidity results in decreased water clarity and increased light energy attenuation due to light scattering and absorption. It may be further intensified by enhanced phytoplankton productivity as a consequence of nutrient input via the outfall system. Burial of hard substrate results in the reduction of suitable habitat available to sessile organisms, burial of organisms, and unusually high particulate loads in the water column immediately above the bottom. The introduction of heavy metals and chlorinated hydrocarbons via the outfall system and subsequent appearance of these sewage constituents among local sediments and floc may result in toxic inhibition of many members of the biotic community.

These physical alterations in the rocky subtidal have resulted in observable changes in the biotic community structure. The intensity of both the physical impacts and resultant biologic effects decrease with increasing distance longshore and inshore of the outfall terminus. Separation of the roles which these three physical impacts play is difficult.

The response of the biological community to the alteration of the physical environment brought about by the outfall discharge may be reduced to three generalized response patterns.

(a) Increased abundance with increasing distance from the point of discharge. This pattern of depression in areas of greatest stress is exhibited by many algae and animal species. A few specific examples follow.

A large number of species, mostly sessile, are depressed in the outfall region. Bryozoan, ascidian, and poriferan species appear to be particularly sensitive and are almost totally absent from the area of greatest impact. These diverse groups are typically strong, competitive members in a healthy, mature community. Absence of these large groups alone would account for a marked decrease in community diversity. Outfall related floc and associated toxicants probably affect the animal community most severely. Fouling of feeding apparatus may occur - ascidans may be particularly susceptible. The absence of many species may be due to decreased settlement or survival of their larvae. These juveniles may be sensitive to substrate contaminants, water column turbidity, substrate burial, loss or obstruction of normal behavioral and chemical mechanisms for substrate identification, and ingestion of toxicants.

As a result of the severe depression in species richness and abundance in the most heavily impacted areas, the limited coverage that does exist is provided largely by an assemblage of diatoms, small filamentous red algae, and two or three species of athecate hydrozoans. In an unstressed environment, this type of community is normally limited to early stages of colonization. In a mature sessile community, competition for space from diverse sessile species, many of which form massive encrusting colonies, masks the presence of these more delicate organisms. The conspicuous nature of this assemblage in those areas of greatest impact results from the lack of this competition. In addition, the algal filaments and basal rhizoidal mats of both living and dead hydroid colonies act as a lattice work holding the floc to the surface of horizontal and vertical faces. This increases the depth and stability of the floc burden upon the substrate, further intensifying the effects of substrate burial.

(b) Enhancement near the outfall, and maximum abundance in areas of moderate to heavy stress from light attenuation, floc deposition and toxicant levels. A few detritus-feeding or scavenging species exhibit this distribution.

(c) Enhancement at intermediate distance form the source of stress.

Motile animal species known to prey upon many of the sessile animal species found off Palos Verdes exhibit this response. Their enhanced abundance is accompanied by an increased richness among encrusting animal species. It appears that decreased algal cover (due to increased turbidity and light attenuation) has provided additional habitat for sessile animals at this distance. This increase in animal coverage may allow the presence of greater numbers of predators. These predators, in turn, may control sessile community structure preventing the establishment of dominants, and thereby enhancing species diversity.

The same three physical impacts which result from solids discharge act in concert on the Palos Verdes macrobenthic algal community: increased turbidity, floc sedimentation and burial of hard substrate, and contamination of floc and sediment by heavy metals and chlorinated hydrocarbons.

The transmittance of sunlight is of special importance in evaluating the impacts of wastewater discharge on the potential growth and reproduction of attached macroalgae, such as the giant kelp Macrocystis, and phytoplankton. Solids discharge can reduce light transmittance in two ways: first, by its contribution of suspended particulate and dissolved colored substances; and second, by its stimulation of phytoplankton productivity.

It appears that JWPCP effluent has a measurable effect on light transmittance in a band extending NW and SE from the Whites Point outfalls, and at shallower stations somewhat inshore from the discharge points. It is ,however, difficult to estimate the magnitude of interference with light transmission. There appears to be a decrease in local euphotic depth ranging from about three meters nearshore to approximately nine meters in deeper water that may be attributed to waste discharge, although the effects of outfall-related particulates on light transmittance must be superimposed on a distinct, natural onshore-offshore turbidity gradient.

This reduction in euphotic depth appears to be the major local impact on attached algae. Algal species richness and abundance are reduced, in the subtidal environment. The most sensitive algae include most brown algal species, such as Macrocystis, Eisenia and Dictyota; these are important determinants of community structure.

Physical burial of hard substate by outfall related floc and elevated toxicant levels associated with this floc may also play a significant role in limiting algal abundance and diversity. In the areas of most intense stress (within 2.7 km or 1.7 miles of the outfall structure) the combined impacts of increased turbidity and floc burden are such that even melobesoid coralline algae are unable to maintain significant coverage. These algae are very successful in areas of lower stress, even when heavily shaded by overgrowing algae.

Various factors, both natural and anthropogenic, limit the distribution of Macrocystis off Palos Verdes. Existing knowledge does not permit separation of these variables in terms of their impact on kelp bed ecology. Kelp bed reductions throughout Southern California provide sufficient indication that Palos Verdes problems are not entirely due to local events, although there do appear to be significant local sources of stress.

Based on historical data of the extent of local kelp habitat, and comparison with wastewater induced reductions in suitable habitat (due to increased light attentuation only), it has been estimated that shoreward compression of Macrocystis and a 32 percent habitat loss has occurred due to Whites Point discharge.

The major sewage-related impacts on the phytoplankton are caused by nutrient enrichment, which can result in moderate eutrophication, and by toxicants, which in sufficiently high concentrations can inhibit growth. The latter effect may be related in part to suspended solids since many toxicants are initially associated with the particulate fraction of sewage.

The effect of current amounts of sewage suspended solids on light transmittance in the water column probably has no more than a minor impact on the phytoplankton, since nutrient measurements indicate that there are often sufficient levels of nutrients within the measured depth of the euphotic zone off Palos Verdes.

Sewage particles are a potential food source for zooplankton as well as a possible means of contamination by toxicants. Very little is known about this aspect of biological effects of the outfall suspended solids.

Demersal fishes are undoubtedly affected by current (and past) discharge practices off Whites Point. In addition to abnormal disease incidence (the fin erosion syndrome extends some 10 km to the northwest of the diffusers, at depths of 61 through 137 meters), the local community of demersal fishes has been disturbed more subtly through alterations in structure and function. Departures from normal community structure include enhancement of some species (such as Dover sole, Pacific sanddab, curlfin sole and California scorpionfish) and depression of others (example: yellowchin sculpin and California tonguefish) in terms of frequency of occurrence and abundance. Noticeable alterations in community function include deficiencies in the normal feeding structure, as evidenced by the loss of species that fill specific roles. The yellowchin sculpin, which feeds on crustaceans (now substantially reduced off Palos Verdes, possibly due to the presence of DDT in local sediments), provides an example of such a loss. In addition, several species that normally fill specific feeding roles have been replaced by more pollution-tolerant species (sole and sanddabs). Another cause of observed community alteration is related to the physical presence and high relief of the outfall structure. Species that would ordinarily be missing (rockfishes, perches, croakers, and sculpins) because of lack of hard substrate habitat have found suitable habitat in the outfall vicinity. (Ref. 506.)

The rocky intertidal reach, important both for its richness and relatively rarity in Southern California, is found in closest proximity to a LA/OMA discharge along the Palos Verdes Peninsula. This region is an interface between terrestrial and marine environments, and has been widely studied as a habitat constantly exposed to natural stress. The urban nature of Southern California in general, and the Los Angeles region in particular, has increased the anthropogenic stress to which the intertidal reach is subjected. In fact, recent studies and state and federally sponsored "mussel watch" programs indicate that much of the Southern California Coast is stressed to some degree (showing a depauperate flora and fauna or having enhanced tissue levels of anthropogenic trace materials, some of which are declared toxicants). Researchers have labelled sewage first (or last) after human trampling and air pollution (at low tide) as causative mechanisms for observed intertidal degradation. However, recent studies report substantial improvements in intertidal algal cover, and species numbers that may be related in some way to past improvements in effluent quality. Significantly, the recent algal studies show complete recovery of species numbers at Palos Verdes to the level recorded at the turn of the century. Percent cover and the dominance of particular species may not have recovered to former levels, but these parameters were not quantified in the earliest studies. This finding, if verified by future studies, would indicate that some sort of threshold for effects may have been reached. (Ref. 506.)

Orange County: Discharge through a subthermocline outfall has occurred since 1971. Thus the period of discharge is relatively short compared to Los Angeles County (25 years) and City of Los Angeles (7 mile outfall - 22 years). Also, the rate of solids discharge is much less than the other LA/OMA operating agencies. In 1977, solids discharged by Orange County Sanitation Districts amounted to about 33 percent of the amount discharged by Los Angeles County Sanitation Districts; 65 percent of the amount discharged through the Hyperion 7-mile outfall; and 42 percent of the total discharged through the Hyperion 5 and 7 mile outfalls. These differences should be kept in mind when comparing presently known or anticipated outfall effects.

The most evident effects on the benthic community are biostimulatory in nature. Initial inputs of organic matter through the new, deep outfall resulted in an increase in density and biomass of benthic invertebrate infauna near the end of the outfall. Infaunal abundance increased to about twice background levels where it stabilized for almost a year. Recently, abundance has declined to below previously noted background levels. An early effect was an increase in normally rare species but calculated species diversity declined as expected, due to changes in the distribution of individuals among species. (Ref. 565.)

Existing data indicate that organic nutrient inputs are being rapidly used by benthic biota resulting in no major buildup of organic matter in sediments around the outfall. No significant increase in sediment organic carbon has been observed. Infaunal biomass increases are largely the result of increases in Parvilucina tenuisculpta (a small clam) and Euphilomedes carcharodonta (a small crustacean), and also increases in a variety of polychaete worms. Species diversity initially declined when the deeper outfall was placed in service in 1971 and remains below pre-discharge levels. Data collected from trawls indicate no reduction in abundance or density of macroinvertebrates (sea cucumbers, starfish, crabs, etc.). The dominant epibenthic community includes sea pens, sea cucumbers (Parastichopus), starfish (Petalaster, Astropecten, and Rathbunaster) and crabs (Mursia and Cancer anthonyi) (Ref. 505.)

Quarterly trawl surveys since 1969 have shown that the abundance of demersal fish in the immediate area of discharge has increased. No significant change in diversity has occurred near the deeper outfall. Dramatic changes in fish abundances and biomass occurred as a result of the change in discharge location from shallow water (18 meters) to deeper water (60 meters). Much of the increased abundance observed near the end of the deeper outfall can be attributed to an increase in the numbers of Dover sole (Microstomus pacificus) and English sole (Parophrys vetulus). (Ref. 505.)

Diversion of effluent to the deeper, longer pipe resulted in a significant decrease in fish abundance near the old, shallow (18-meter depth) outfall. The greatest decline was noted in three species: white croaker (Genyonemus lineatus), queenfish (Seriphus politus), and northern anchovy (Engraulis mordax). Benthic community structure also recovered rapidly, biomass and frequency of indicator species (Capitella, Parvilucina) declined along with organic matter and hydrogen sulfide. (Ref. 505.)

Air/Water Interface

As secondary consumers, birds and mammals are at higher levels in the marine food web and can be affected by substances which have been concentrated in lower organisms.

The California brown pelican (Pelecanus occidentalis) suffered a severe decline in population in both its California and Mexican habitats in the 1960s. This decline was due in large measure to DDT discharge into the marine environment. One consequence was virtually complete reproductive failure among the Pelican colony occupying Anacapa Island offshore of the Oxnard-Ventura coast. The decline is now slowing and improved reproduction concomitant with decrease in pesticide residue in pelican eggs has been noted. At the same time DDE levels in anchovies, the main food of pelicans, has declined significantly (Ref. 502). More recently a new decline in the brown pelican population has been observed, possibly from a severe reduction in coastal anchovy populations. The decline in anchovy population has been attributed to natural, but adverse, oceanographic changes during the late winter anchovy spawning season. (Ref. 506.)

Studies indicate that high mortality rate (50 percent) among sea lion (Zalophus californianus) pups may be related to contaminants such as chlorinated hydrocarbons, trace metrals, or microorganisms. (Ref. 505, 502.)

The California grey whale (Eschirichtuis robustus) migrates through the Southern California Bight far offshore of coastal regions. Instances of feeding during migration have been reported on rare occasions. It is believed that sludge disposal via LA/OMA outfalls has no effect upon this species. (Ref. 550.)

Bioaccumulation

Although toxicants may be released from sewage outfalls in low concentrations and diluted even more by mixing with the ocean waters, many marine organisms are able to concentrate these toxicants in their tissues (bioaccumulation). Toxicants in the water in concentrations too low to cause any noticeable effect in short-term laboratory tolerance studies, may be concentrated in the organism's tissues to produce a long-term lethal or sublethal impact. The concentrated toxicants may then be transferred through the food web. This transfer of toxicants from one trophic, or food, level to the next higher, with concentration of tissue levels of the pollutant during that step, is known as biomagnification. (Ref. 502.)

Predictions of the effects of biomagnification on top carnivores (including marine birds, game fish, marine mammals, and man) must be approached cautiously because the rate of accumulation and body turnover time (often expressed as biological half life) varies among species and among toxicants. The location of accumulation within the body also varies among toxicants. Chlorinated hydrocarbons and some metals are characteristically accumulated most strongly in the liver. For example, DDT levels in Palos Verdes Dover sole livers were 15 times the mean concentration in muscle, gonad, heart, and kidney tissues (Ref. 566). To a predatory fish or bird that eats its prey whole, the location of the toxicant in the prey is immaterial. To man, who eats only the muscle of most fish, it is of great importance. (Ref. 502.)

Toxicants released by sewage outfalls into the marine environment may reach man by transfer or biomagnification through the marine food web. Toxicants released in the wastewater or eluted from the sludge particulates may be carried long distances by either ocean currents or food organisms. (Ref. 502.)

Trace Metals: Studies by SCCWRP indicate that while some trace metals are elevated over controls, trace metals are not concentrated in muscle tissue of sportfish substantially above levels measured in control areas. Similarly, flatfish, living in sediments highly contaminated by sewage solids, do not accumulate trace metals, except mercury, to any degree above natural levels. (Ref. 504.) Until the mechanism(s) governing bioaccumulation are better understood, including antagonism, synergism, and speciation among toxicants, some caution is urged in interpretation of the data available. New studies on trophic structure may be very helpful in this respect. (Ref. 556).

Bioassay studies do not as yet permit evaluation of the relationship between elevated levels of metals in sediments around outfalls and viability of subtidal benthic invertebrates. The apparent lack of uptake by fishes feeding on these invertebrates suggest that metals in contaminated sediments are not undergoing biomagnification. (Ref. 505).

In contrast to fishes (Ref. 556.), some invertebrates do show enhanced trace metal burdens. A survey of approximately 25 trace metals in the intertidal mussel, Mytilus californianus, revealed no apparent relationship between proximity to a specific point source and elevated tissue metal concentrations. However, for many metals coastal concentrations were approximately double the levels found in island specimens. Perhaps diffuse sources (or dispersion of discrete inputs) in the Bight are causing a detectable increase in metal levels in the marine biota along the coast between Santa Barbara and San Diego. The highest coastal-to-island ratio was for lead (approximately 3:1), apparently reflecting input from aerial fallout. (Ref. 505.)

SCCWRP has shown that rock scallops (Hinites giganteus) collected near the LACSD discharge are accumulating trace metals above normal levels. Rock scallops appear to be able to concentrate at least six potentially toxic metals in their gonadal and muscle tissues to levels at least twice normal concentrations. (Ref. 510.) Other studies have shown metals uptake by abalone, lobster, and mussels (Ref. 504, 506).

The relatively low cadmium levels found in some tissues of organisms living around the Palos Verdes outfalls may be related to the high levels of DDT residues that have accumulated from historic discharges. This would be similar to the case in which exposure of penaeid shrimp to methoxychlor (a chlorinated hydrocarbon pesticide somewhat similar to DDT) appeared to depress the muscle tissue concentrations of cadmiun in this organism. (Ref. 510).

Trace Organics: In the 1970s there has been great concern about DDT contamination of seafoods, particularly off Palos Verdes. The discharge of DDT from the Whites Point outfall system was virtually eliminated in 1970. Los Angeles County emissions dropped from approximately 100 MT in 1970 to less than 4 MT in 1973, and continue to decline. DDT levels have declined recently in both animals and surface sediment. (Ref. 555). Following are data from the period when highest DDT contamination was reported.

Studies of samples of the market crab (Cancer anthonyi) collected in 1971-72 did not disclose values in excess of the FDA limit (5 parts per million wet weight). DDT values were highest in animals from the Palos Verdes shelf. Values for PCB were reported to be similar for the areas sampled. Both DDT and PCB levels in crabs living near the end of the 7-mile outfall were significantly higher than in those inhabiting other sections of Santa Monica Bay. (Ref. 548.)

In 1971, DDT concentrations in whole soft tissues of the intertidal mussel (Mytilus californianus) were clearly detectable above baseline concentrations for over 100 km in most directions from the Whites Point outfall. A maximum concentration of 4,200 μg/wet kg was observed. Although the discharge of DDT was greatly reduced by 1974, concentrations in Palos Verdes specimens were 100 times higher than control station values. (Ref. 549). Since then DDT and PCB tissue levels have further declined, but much less dramatically (Ref. 555).

More recent data on trace organics in seafood have been obtained from species collected during 1975-77 from the Palos Verdes Peninsula and from control stations off Catalina Island and Dana Point. Three specimens of each of the following species were analyzed: Pacific bonito (Sarda chiliensis), northern anchovy (Engraulis mordax), kelp bass (Paralabrax clathratus), scorpionfish (Scorpaena guttata), red sea urchin (Strongylocentrotus franciscanus; gonadal tissue), yellow crab (Cancer anthonyi), spiny lobster (Panulirus interruptus), California mussel (Mytilus californianus; whole soft tissues), purple-hinge scallop (Hinnites giganteus), and black abalone (Haliotis cracherodii). (Ref. 541). Table 22 shows that whereas mean tissue concentrations of DDT and PCB residues approached the FDA seafood guidelines (viz. 5 mg/wet kg total DDT and 2 mg/wet kg total PCB) within a factor of 10, corresponding HCB (hexachlorobenzene) values were, on the average, 1,000 times below the FDA guideline for meat of 0.0003 mg/wet kg. Based on these data, SCCWRP has concluded that it seems unlikely that chlorinated benzenes constitute a health hazard in seafood caught off Southern California outfalls. (Ref. 541.). Further studies are being conducted on DDT and PCB levels, however, particularly since levels of environmental and tissue contamination appear to be declining. (Ref. 555.)

Some of the highest concentrations of synthetic organic contaminants have been found in livers of flatfish trawled for the Los Angeles County and City of Los Angeles discharge zones. Therefore, SCCWRP conducted a study in which liver tissue was analyzed from six Dover sole (Microstomus pacificus) collected during April-May 1977 from near the Los Angeles County outfall, six Pacific sanddab (Citharichthys sordidus) collected in October 1978 from near the Hyperion 7-mile outfall terminus, and three Dover sole collected during November 1978 from the Dana Point control station. Results from these analyses, summarized in Table 23 indicate that with the exception of 1, 2, 4-TCB in the Hyperion 7-mile outfall specimens and possibly Los Angeles County outfall samples, the di- and trichlorobenzenes were not detected in livers of flatfish known for their high DDT and/or PCB levels. In contrast, HCB was detected well above procedural blank levels. (Ref. 541.)

The University Task Force (Ref. 539) which evaluated water quality effects of Hyperion sludge discharge does not recommend eating fish caught in the vicinity of the Hyperion outfalls because of concern regarding accumulation of halogenated hydrocarbons.

As discussed in previous sections, trace organics in food are documented to affect birds (DDT destroys calcification mechanisms) and may also affect mammals.

Pathogenic Organisms: Very little data is available on the fate of pathogens discharged to the ocean in municipal discharges. (Ref. 561.) Mussels and other shellfish are efficient concentrators of bacteria and viruses, and provide a means of measuring contamination. (Ref. 525).

TABLE 22

MEAN (±1 STD. ERROR) CONCENTRATIONS IN MUSCLE TISSUE OF SEAFOOD FROM LOS ANGELES COUNTY DISCHARGE ZONE AND CONTROL SITE (1975-1977)

(milligrams per wet kilogram)

	OUTFALL				CONTROL			
	HCB (a)	PCB	DDT	n	HCB (a)	PCB	DDT	n
FISHES								
Bonito	0.0006 ±0.0003	0.31 ±0.10	0.83 ±0.27	3	0.0006 ±0.0002	0.39 ±0.12	1.1 ±0.4	3
Anchovy	0.0004 ±0.0001	0.07 ±0.02	0.30 ±0.05	5	0.0001 ±0.0001	0.036 ±0.010	0.24 ±0.15	3
Kelp Bass	0.0002 ±0.00004	0.30 ±0.10	1.6 ±0.3	6	0.0 (b) ---	0.033 ±0.010	0.030 ±0.014	3
Scorpionfish	0.0001 ±0.00001	0.57 ±0.14	3.6 ±0.7	4	0.0001 ±0.00003	0.043 ±0.017	0.097 ±0.033	3
INVERTEBRATES (c)								
Sea Urchins	0.0005 ±0.0001	0.091 ±0.016	0.34 ±0.071	6	--- ---	--- ---	--- ---	--
Crab	0.0001 ±0.00003	0.37 ±0.16	1.5 ±0.2	5	0.00 ---	0.032 ±0.0006	0.004 ±0.002	3
Lobster	0.0 ---	0.10 ±0.05	0.56 ±0.26	5	0.00 ---	0.010 ±0.004	0.003 ±0.001	3
Mussel (d)	<0.0001 ---	0.17 ±0.4	1.4 ±0.3	9	--- ---	--- ---	--- ---	--
Scallop	0.0 ---	0.014 ±0.001	0.15 ±0.01	9	0.0 ---	0.004 ±0.002	0.040 ±0.017	10
Abalone	0.0002 ±0.0002	0.08 ±0.06	0.0009 ±0.0003	5	0.0 ---	0.023 ±0.011	0.0001 ±-.0001	3

Source: "Chlorinated Benzenes in Southern California Municipal Wastewater and Submarine Discharge Zones", Young, David R., et.al., (November 7, 1979).

(a) n=3 except as otherwise indicated.
(b) Negative net signal.
(c) Gonads. n=6 for HCB.
(d) Whole soft tissue. n=9 for HCB.

TABLE 23

MEDIAN AND MEAN CONCENTRATIONS (± 1 STD. ERROR) OF CHLORINATED BENZENES, PCBs, AND TOTAL DDT IN LIVERS OF FLATFISH

Station	p-DCB	o-DCB µg/wet kg.	TCB	TCB	HCB	1242 PCB mg/wet kg	1254 PCB	Total DDT
Hyperion: 7-1								
Median	<1.2	(a)	29	0.0[(b)]	24	3.3	19	27
Mean	<67	(a)	26	3.2	25	3.5	19	26
S.E.	±52	(a)	±6.2	±3.2	± 3	±0.7	± 5	± 4
Los Angeles County 32								
Median	9.0	0.0	<1.5	<0.4	31	3.3	10	230
Mean	24	4.0	<3.4	<1.1	60	8.4	28	440
S.E.	±15	±3.0	±1.7	±0.7	±31	±5.3	±20	±230
Los Angeles County 33								
Median	0.0	0.0	4.3	<0.1	56	4.1	17	270
Mean	3.9	0.17	5.7	<0.4	58	4.4	15	350
S.E.	±2.4	±0.17	±1.9	±0.2	± 6	±0.9	± 3	±130
Los Angeles County 34								
Median	<14	(a)	<0.7	<2.5	23	3.6	12	210
Mean	<34	(a)	<7.9	<5.7	24	3.7	12	200
S.E.	±18	(a)	±6.0	±3.0	± 4	±0.3	± 1	± 20
Control: 51								
Median	0.0	0.0	0.0	0.0	0.6	0.039	0.017	0.74
Mean	0.0	0.0	0.0	0.3	0.7	0.041	0.036	0.60
S.E.	---	---	---	±0.3	±0.4	±0.024	±0.028	±0.19
Median Blank	3.3	82	<1	1	<0.4	0.026	0.016	<0.006
Mean Blank	<17	150	<9.8	<1.7	1.5	0.17	0.072	<0.055

(a) Values dropped due to erratic blanks.
(b) Negative net signal.

Coliform concentrations in nearshore Southern California waters have been monitored extensively for many years. Studies conducted by the City of Los Angeles in Santa Monica Bay since 1960 have correlated higher coliform concentrations in surface water samples from December to March with seasonal destratification of the waters. (Ref. 505.)

Coliform concentrations tend to be higher in both surface and subsurface samples at stations closer to the shoreline than at stations further offshore. Coliform concentrations along the beaches are affected greatly by surface runoff, and a strong correlation exists between rainfall with its consequent runoff and coliform concentrations in the littoral (surf) waters. (Ref. 505.)

Coliform bacteria are observed associated with macroparticulate samples taken from surface slicks over wastewater outfall stations. Concentrations associated with macroparticulates near Hyperion's outfall ranged from 3,000 to 150,000 per square meter of surface area (collected by capillarity with a screen). During this study, the material was observed to move under influence of prevailing winds at a rate of 0.2 to 0.5 knots. Methods employed in this study required clear, calm weather - wind speeds less than 7 knots - to observe and sample surface slick material. (Ref. 503.)

SCCWRP has measured the concentrations of viruses in the digestive glands of mussels from buoys and at shore-stations near outfalls, and determined the relationship between virus and coliform concentrations in mussels and seawater. Table 24 lists the results for the 16 buoyed mussel samples in which virus plaques were detected and quantified. Mussels concentrated coliforms (and presumably viruses) to about three orders of magnitude higher than in dilute solution in the field. Viruses appear to survive relatively longer (three to six times) in mussels and seawater than do bacteria. Two shore stations in Santa Monica Bay had detectable viruses. (Ref. 525.)

Thus it appears that the incidence and survival of bacteria and viruses is significant. In fact, the stability of human enteroviruses in estuarine and marine waters has been found to be such that infectious virus can be recovered after 46 weeks (Ref. 561). Moreover, antibiotic-resistant and heavy-metal-resistant coliforms have been isolated in estuaries and the ocean (New York Bight). Studies in Puget Sound have revealed high counts of Clostridium perfringens in fish and sediment near the Seattle sewage disposal plant also. The importance of enteric viruses lies not in their numbers but in their infectivity. Techniques for isolation and characterization of viruses are being developed, and it is anticipated that monitoring programs will eventually be established to address current concerns about this environmental hazard.

Diseases and Abnormalities

The possibility that wastewaters discharged into coastal waters are responsible for triggering diseases in marine organisms has generated much concern and

TABLE 24

TOTAL COLIFORM AND ENTEROVIRUSES IN SEAWATER AND DIGESTIVE GLANDS OF *MYTILUS CALIFORNIANUS* SUSPENDED FROM BUOYS

Location and Water Depth	Date Sampled	Total Coliform		Viruses in Mussels (PFU/kg)(a)	Ratio, Coliforms to Viruses in Mussels
		Seawater (No./liter)	Mussels (No./kg)		
Santa Monica Bay					
15 m	3/6/76	4×10^3	7.9×10^6	263	3×10^4
45 m	3/6/76	8×10^3	3.5×10^7	140	2.5×10^5
45 m	2/11/76	ND (b)	7×10^7	30	2.33×10^6
Palos Verdes					
Buoy 1					
30 m	3/ 1/76	7×10^3	1.1×10^7	114	9.65×10^4
Buoy 2					
16 m	5/ 3/76	1×10^2	3.48×10^7	620	5.61×10^4
16 m	5/17/76	1.2×10^3	1.2×10^8	552	2.17×10^5
32 m	5/ 3/76	5.9×10^4	3.48×10^7	1,475	2.36×10^4
32 m	5/17/76	7×10^2	7.8×10^6	210	3.71×10^4
32 m	6/ 1/76	8.4×10^3	8.6×10^6	321	2.68×10^4
Buoy 3					
17 m	10/ 3/75	5×10^2	4.9×10^5	41.7	1.18×10^4
25 m	10/30/75	3.7×10^2	1.2×10^6	105.3	1.14×10^4
32 m	10/ 3/75	1.1×10^3	8×10^6	315.8	2.53×10^4
32 m	10/30/75	1.7×10^3	4×10^6	263.2	1.52×10^4
Orange County					
Surface	2/ 6/76	ND (b)	9.2×10^8	91	1.01×10^7
15 m	2/ 6/76	ND (b)	9.2×10^8	476	1.93×10^6
45 m	2/ 6/76	ND (b)	3.1×10^7	25	1.24×10^6

Source: "Viruses and Bacteria in Coastal Waters and Shellfish", Morris, Rodney L., et.al., SCCWRP, (1976).

(a) Values given do not reflect an estimated efficiency of recovery of 35 percent.
(b) ND, no data.

stimulated needed local research. Fin erosion, tumors, ambi-coloration, skeletal deformities, external deformities, and exopthalmia (protruding eyeballs) are found in fishes caught in Southern California. (Ref. 505.). However, fin erosion is the only condition that appears to be directly associated with wastewater discharge. (Ref. 546).

Fin Erosion: The most frequent occurrence of this syndrome is in Dover sole (Microstomus pacificus). Other species frequently affected are the rex sole (Glyptocephalus zachirus), the slender sole (Lyopsetta exilis), the greenstriped rockfish (Sebastes elongatus) and the vermilion rockfish (Sebastes miniatus). (Ref. 546.)

Highest frequency of the disease is in the vicinity of the diffusers on the Palos Verdes shelf. Although the Palos Verdes shelf appears to be the primary site at which fin erosion is initiated, there is evidence that the disease may also be developing near the terminus of the Hyperion 7-mile sludge outfall. SCCWRP has found 14 percent prevalence of fin erosion in Dover sole collected from trawls at 152 meters depth directly off the end of that outfall in October 1978. The University Task Force has reported that over 10 percent of the Dover sole and white croaker collected in the vicinity of the 7-mile sludge line show evidence of fin erosion disease (Ref 539). Some 39 percent of the Dover sole collected on the Palos Verdes shelf between 1972 and 1976 had eroded fins (Ref. 546).

It has been postulated that Dover sole with fin erosion collected in the vicinity of the Orange County outfall (2 percent) had migrated there from the Palos Verdes shelf. Physiological relationships (size of fish versus disease, DDT/PCB ratio in tissues, and liver-somatic index) were used to support this conclusion. (Ref. 546.) Perhaps the short history of discharge and the relatively uncontaminated nature of local sediments has slowed the appearance of the fin erosion syndrome.

Fin erosion appears to result from exposure of susceptible species to sediments contaminated with chemical wastes. The mechanism involved in development of the syndrome are not known. It appears, however, that exposure to PCBs may be a factor, although data collected to date do not prove this to be the cause, nor do they eliminate other contaminants as contributing factors. (Ref. 546.)

The prevalence of fin erosion may be decreasing on the Palos Verdes shelf. However, additional surveys will be required to determine the validity of the trend. (Ref. 546.)

Liver Anomalies: Enlarged livers, containing increased amounts of fat and exhibiting structural disorganization, have been observed in Palos Verdes shelf Dover sole which exhibit fin erosion. The enlarged liver condition has also occurred in Dover sole with apparently unaffected fins, in specimens from Santa Monica and San Pedro Bays, and in other demersal fish species in which the prevalence of fin erosion is low or undetectable. Liver somatic indices (ratio of liver weight to body weight multiplied by 100) were highest in specimens from the Palos Verdes shelf. Although liver size and fat content are affected by factors such as diet, reproductive condition, and disease, they also appear to change in relation to exposure to chlorinated hydrocarbons. SCCWRP has suggested that increases in tissue burdens of chlorinated hydrocarbons are associated with increases in the degree of liver enlargement and fat accumulation. Both fin erosion and liver anomalies appear to be indicators of depressed environmental health. (Ref. 546.)

Summary

This section describes what is known of present and past impacts on LA/OMA discharges on the marine environment. Following are five types of problems which account for the incomplete, and yet state-of-the-art, description of impacts: 1) a lack of knowledge of physical processes such as sedimentation and circulation in coastal waters, 2) sampling has been carried out (until very recently) using grids that were too coarse, both spatially and temporally, to resolve localized changes around the outfalls and in coastal waters, 3) sampling and analytical techniques of the various agencies involved have not been comparable - a situation which has improved recently, 4) laboratory bioassay data has been of limited utility in assessing the potential acute and/or subtle effects of wastewater constituents on organisms, and 5) LA/OMA municipal discharges represent only one source of pollutants to the Bight, and it is difficult to readily distinguish outfall (or sludge) effects from those of the other pollutant sources. It is evident that more detailed and long-term studies must be undertaken to fully assess the impacts of LA/OMA discharges on the marine environment.

- There have been substantial alterations of the bottom sediments in the vicinity of sludge discharges. These changes include an accumulation of the sludge particulates which readily settled and which contain a significant fraction of their original toxic constituents, and higher (than background) organic fraction.

- The percentage of the particulates that remain in the vicinity of the outfalls is uncertain. Calculations suggest that a substantial proportion of those that have been released still remain, but definitive data are lacking. Similarly, the ultimate fate of these settleable particulates, be it displacement by turbidity currents, eventual resuspension and wide distribution, or permanent deposition where first settled is not known. Some evidence is presented for each of these possibilities, but none of the evidence is conclusive. The best available estimates are from models by Hendricks. (Ref. 553.)

- Laboratory studies have shown that some toxic substances are mobilized from suspended particulates, although this has not been demonstrated in situ. However, evidence has been presented that once the particulates settle to the bottom , further mobilization occurs slowly, if at all. The percentage of those toxic substances released from the outfalls that eventually end up distributed in the water rather than trapped in the sediments has not been adequately estimated, either theoretically or empirically.

- The distribution of sewage constituents in the water column has been documented to a much lesser extent than that in the sediments. Data show that in summer there is a thermocline which inhibits bacteria of plume origin from reaching the surface, and hence, nearshore waters. Thus, contamination of the shoreline by the plumes during summer is not likely to occur. In winter, plumes apparently surface and may reach shore. Upwelling is another potential means of bacterial contamination surfacing and reaching nearshore waters.

- Wastewater discharges may potentially reduce the dissolved oxygen content of the receiving waters, especially near the bottom. The dissolved oxygen concentrations in the water column near the outfalls, however, do not appear to be lowered significantly by waste discharge. The three nearshore basins (San Pedro, Santa Monica, and Santa Barbara) have naturally reduced oxygen levels below the sill depth as a result of bacterial decomposition of organic matter settling out from the natural high productivity (compared to offshore) of the surface waters. Wastewater discharges along the coast may contribute to this organic matter directly (Santa Monica Canyon) or indirectly (Palos Verdes and San Pedro shelves).

- The distributions of some benthic organisms living in the sediments are correlated with the areas of known physical/chemical alteration. There has been a substantial alteration in the biological characteristics of the bottom within the influence of the outfalls discharging sludge. Decreased diversity and increased abundance occur, and this is by most definitions a degradation of the environment.

- Muncipal discharges have been shown to periodically influence plankton in the surface waters. There is disagreement as to whether productivity is actually elevated in the surface waters over outfalls. Greater local enhancement of phytoplankton has coincided with periods of intrusion of the Whites Point waste field into surface waters. Maximum productivity potential predicted from nutrient concentrations has not in all cases been achieved, apparently as a result of the toxicants released with the nutrients. In the past, the occurrence of red tide blooms has shown no direct relationship to the outfalls .

- There is considerable evidence that heavy metals and chlorinated hydrocarbons released from outfalls could be directly toxic to marine organisms. The concentrations of some constituents in the undiluted effluent are likely to be directly toxic to some marine organisms, and even after 100:1 dilution, some constituents may be toxic to some organisms.

Much more pervasive is the possibility that the constituents being released from the outfalls may cause gradual sublethal effects throughout the food web and result in an altered species composition. More bioassay work is clearly indicated, especially with regard to effects on larval forms, reproduction, physiology and behaviour. The observed community structural changes are the result of subtle chronic not grossly acute effects. These toxicants may be bioaccumulated in individual organisms, concentrated through the web, and ultimately interfere with reproductive success of marine birds and mammals or they may appear in human food supplies. Chlorinated hydrocarbons have been found in the tissues of sport and commercial fish and in marine mammals and birds, where they are known to have deleterious effects. It has not been possible to trace any such contamination directly to municipal discharges but since organisms in the Bight do concentrate these substances and since municipal discharges are large sources of them, it can be inferred that some percentage of the uptake is attributable to outfalls.

- Marine wastewater discharges appear to increase the incidence of fin erosion and liver anomalies in fish. On the contrary, most evidence indicates that the incidence of tumors is apparently unrelated to wastewater outfalls.

In marine and shore birds thin eggshells have been caused by DDE (a metabolite of DDT); this reduced their reproductive success. The population of California brown pelicans declined in recent years as a result of this, but the decline appears to be reversing as DDT pollution is abated.

Premature pupping in California sea lions may be related to DDT, PCBs and/or heavy metals such as mercury, cadmium, and selenium as well as bromine.

- A great deal of information is available on the distribution and concentration of sewage constituents in the sediments and on the distribution and abundance of benthic organisms. Neertheless, more detailed and long-term data are necessary in such areas as reproduction, colonization, bioaccumulation and bioassay before the impacts of sludge discharge on the biota of receiving waters can be fully assessed or predicted.

POTENTIAL IMPACT ON MARINE BIOTIC RESOURCES FROM ALTERNATIVE SLUDGE MANAGEMENT PROJECTS INVOLVING OCEAN DISPOSAL

IMPACTS ●

MITIGATION MEASURES ●

POTENTIAL IMPACT ON MARINE BIOTIC RESOURCES FROM ALTERNATIVE SLUDGE MANAGEMENT PROJECTS INVOLVING OCEAN DISPOSAL

Sludge contains constituents that can have a positive effect upon marine organisms when properly released into the marine environment. Other constituents in the sludge, however, can produce detrimental effects. Whether impacts are short-term or long-term in nature depends upon the marine community affected. Certain effects are now readily observable, other more subtle effects can only be deduced. Marine biological resources in the Angeles/Orange County Metropolitan area are not in pristine condition. Stress is apparent in several specific cases. Broad scale effects appear to have resulted from both accumulation of pollution impacts and overutilization of resources.

Short-term effects occur relatively soon after the biological system is perturbed and have received much greater attention since they are more apparent and measurable. On the other hand, long-term impacts are generally subtle, and may result from accumulation of a series of small effects or from a set of infrequent but periodic circumstances over a long time period. As such, long-term effects have not been studied extensively in Southern California waters and can only be examined through inference and application of conclusions developed largely from laboratory studies.

Whether impacts are reversible or not depends upon the extent to which biological populations are locally adapted to specific sites and the time scale considered. The flora and fauna of sandy bottom sites have been observed to return to near normal within several years after a discharge site has been moved (Ref. 505). Whether the rocky bottom communities are as resilient remains to be determined. There is evidence of partial recovery on the Palos Verdes shelf; this has been attributed in part to decreases in toxic elements in sludge, and to more effective removal of particulate matter.

The professional community are divided in opinion on the existence of threshold levels for toxicants. Some argue that such threshold levels must exist, particularly for those toxicants (e.g., trace metals) that occur naturally in the environment. A second group argues against the existence of such threshold levels and maintains that there is a direct relationship between toxicant concentration and the intensity of harmful effects: concerns involve sublethal effects on genetics, behavior, and reproductive capability. This divergence of opinion is not unexpected since effects vary with factors such as species, age, and physiological condition of affected organisms, since there are limited means of measuring effects and applying the results to open ocean situations, and since viewpoints regarding the significance of the anticipated response vary.

The significance of the effects of sludge discharge to the ocean are difficult to define. Historic benthic impacts appear to be confined largely to areas around the individual outfalls. Much of the sludge, however, is dispersed by ocean currents, and some may be transferred to the bottom of nearby deep ocean basins. Long-term sublethal effects are immeasurable in the field, as are most effects upon reproductive capability and success, behavior, or genetics. There are also potential human health effects.

Describing the impacts of discrete sources upon open coastal water ecosystems is a formidable task. Assessments of the effects of past and projected discharges are made most easily in terms of bottom dwelling organisms and non-migratory species. Projecting future effects, considering the uncertainties of an incomplete data base, and future treatment levels and source control, is a difficult but necessary task.

Impacts resulting from the Baseline Alternative have been defined largely through review (and extrapolation) of observed local effects which result from present and past discharge practices, through physical/biological mathematical modeling, and through examination of discharge termination studies at other sites.

Information on which to base potential impacts under the Deep Ocean Outfalls and Barge Disposal Alternatives are very sparse (Ref. 564). Where possible, however, impacts were predicted through inference and limited application of Baseline Alternative assessments. Obviously, more study of these alternatives is needed to adequately predict their impacts upon the marine biota in the receiving waters.

It is apparent that the best indications of the biotic effects of sludge disposal in the ocean are the Palos Verdes outfalls (shallow disposal) and the Hyperion 7-mile outfall (deeper disposal), which have been detailed in the preceding section "Effects of Existing Outfall Systems". The most extensive studies have been made on the Palos Verdes shelf, where large volumes of waste have been discharged in an ecologically complex area, with significant impacts from both solid and trace contaminant fractions of the sewage.

IMPACTS

Impacts on marine biota from sludge discharge to the ocean are relatively site specific and project dependent. Thus, description of such impacts are presented according to projects and specific sites when necessary.

Baseline "No Project" Alternative (6S1)

Under this alternative, the level of ocean discharge of wastewater solids would be reduced from current practice. This alteration results from improved wastewater treatment (recall that full secondary treatment of all wastewaters is assumed) which reduces the amount of solids remaining in the effluent after treatment (effluent solids); installation of interim sludge dewatering and processing facilities, which reduces the amount of digested sludge to be discharged (sludge solids); and projected increases in the production of sludge. The effects of each of these factors varies with each operating agency.

Using data on the composition of municipal discharges under the Baseline Alternative and the timing of treatment improvements provided by LA/OMA Project, the Southern California Coastal Water Research Project (SCCWRP) has provided projections of effects of the Baseline Alternative on the marine environment. (Ref. 540.) These projections were based upon sludge quantities projected for the year 1985 and sludge characteristics assuming 1977-78 levels of industrial source control.

Subsequent to the above studies, each of the LA/OMA operating agencies prepared and submitted applications to EPA for waiver of secondary treatment requirements pursuant to Section 301(h) of the Federal Water Pollution Control Act (1977 Amendments). Where appropriate, information from these applications has been used to supplement the aforementoned studies.

The list of independent projections made by SCCWRP, which provide a substantial basis for determination of impacts under the Baseline Alternative, are as follows:

- Changes in bottom near Los Angeles County (Whites Point) and Orange County outfalls, as determined by a mathematicl model using data on organic carbon, DDT, and copper concentrations in sediment.
- Changes in benthic indicator organisms as reflected by the Infaunal Trophic Index.
- Changes in biomass of benthic infauna.
- Changes in epibenthic invertebrates.
- Changes in the abundance of bottom fish.
- Changes in fish health.
- Changes in water column and plankton (dissolved oxygen, phytoplankton, zooplankton).
- Changes in sport and commercial fish catches.
- Changes in nearshore bacterial levels.
- Changes in chlorinated hydrocarbons and metals.

The ten independent projections each deal with a criterion and together provide a description of the conditions expected to exist around the LA/OMA outfalls under the Baseline "No Project" Alternative. There are, of course, assumptions and uncertainties associated with each projection. As such, great reliance should not be placed upon any single number. However, the collective view is believed to be reasonably accurate.

The assumptions underlying the projections by SCCWRP and the evaluation of each assumption are as follows:

- Full secondary treatment of wastewaters is assumed to occur by January 1983.

  Many factors (e.g., status of applications for waiver of secondary treatment requirements) affecting timing of secondary treatment facilities are as yet uncertain. However, each of the LA/OMA operating agencies has secondary treatment facilities currently in operation or under construction. Until final decisons on waiver applications are made, full secondary treatment continues to be required and will be required if waiver applications are denied. It is doubtful that substantial changes in projected effects would result from variations in the assumption, although timing of effects could be affected.

  diffuse sources other than the assumed changes in municipal discharges.

  While it is likely that some changes in the pollutant inputs will occur, SCCWRP believes such inputs will stay at about present levels.

- There will be no changes greater than normal variations in ocean conditions (temperature, currents, waves, etc.) or in biological input to the Southern California Bight (plankton, larvae, fish, etc.).

  Projections concerning changes in the diversity and abundance of marine life near outfalls are based on both average and specific conditions observed during the past five years. Major climatic and biological episodes (50 and 100 year floods and invasions for example) can affect the diversity, abundance, and biomass of marine life. The magnitude and duration of these changes are unpredictable. SCCWRP believes, however, that they do not affect basic aspects of nearshore community structure and diversity over periods of several decades.

- Sludge is equivalent to suspended solids in municipal wastewater that reach the sea, whatever their origin. The settling velocity distribution beyond 1983 will be the same as in 1973, or as estimated from laboratory study.

  The present Settling Velocity Distribution (SVD) is based on past experiments of settling velocity. Most of these experiments probably show a high SVD which means that particle dispersion fields could be slightly larger than those predicted by the SVD. Pending further experimentation, the assumption is a reasonable first approximation.

If suspended solid particle settling time is reduced by future treatment techniques, particles will settle more slowly as long as no increased aggregation also results from the treatment. If the settling velocity distribution is reduced, the area over which the particles are dispersed prior to reaching the bottom will increase. Additional processing of suspended solids in the future (full secondary treatment) may cause this to happen.

- There is no significant desorption of either chlorinated hydrocarbons or metals from particles on entering the sea.

  The low solubility and rate of desorption observed for DDT and PCBs indicates that this is a reliable assumption for such trace synthetic organics. The assumption is less reliable for trace metals. However, metal desorption rates generally are lower than typical dilution rates following discharge. Thus, concentrations of dissolved metals should not be elevated much above background. This has been confirmed by field tests.

- The die-off rate of coliforms, pathogens, and viruses reaching the sea will be the same as that measured in the past.

  There is no direct information that would allow projections of an increase or decrease in the die-off rate. Some organisms surviving secondary treatment could be more resistant than those presently discharged, and a change in the ratio of bacteria to solids could cause a significant change (increase or decrease) in the die-off rate.

- Elevated levels of metals in filter-feeding or deposit-feeding animals is due to consumption of or contact with waste particles either directly from an outfall or stirred from the bottom, but not to metals in solution.

  Although marine animals will accumulate trace metals from solution, it appears this requires aqueous concentrations well above (>> 1 ppb) those encountered near submarine discharges (≤1 ppb).

- Any elevated levels of chlorinated hydrocarbons in bottom-feeding fish or invertebrates are related to chlorinated hydrocarbons on waste particulates in the bottom.

  This assumption is based on the fairly similar rates of decrease observed for DDT-PCB in bottom sediments and benthic organisms around the Whites Point and Orange County discharges.

Impacts upon marine biotic resources which result from discharge of digested sludge solids to the ocean through existing outfall systems may be nonsite specific and apply to all outfall areas, or definable for individual outfall areas.

Potential Nonsite Specific Impacts

Tumors in fish (either skin tumors or lip papillomas) do not appear to be related to municipal discharges. Thus, prevalence of such tumors will not be changed by reduction in solids discharges. (Ref. 540.)

There will be no measurable increase in dissolved oxygen concentrations in waters near LA/OMA outfalls. Currently, dissolved oxygen concentrations at any depth near the outfalls are not depressed more than 10 percent below background conditions. (Ref. 540.)

There should be no demonstrable decrease in phytoplankton productivity. It is, however, possible that increased blooms could occur if toxicity of effluents are reduced and increased light penetration is achieved. The Palos Verdes area is the site most likely to meet these criteria. (Ref. 540.)

There should be no demonstrable decrease in zoopankton volumes as the result of reduction in solids emissions. However, because zooplankton abundances may be related to phytoplankton production and because there is a possibility of increased phytoplankton growth at some sites, there may be slight increases in zooplankton abundances. Large year-to-year variations in zooplankton abundances and composition will continue to occur. (Ref. 540.)

effort as the result of reduction in solids emissions. Reduction in catches of white croaker may, however, be noted off Palos Verdes and in Santa Monica Bay since the biomass of benthic organisms (their food) is projected to decrease. Sportfish catches and catch composition will continue to demonstrate year-to-year fluctuations due to natural changes in water temperature, recruitment success, and other large-scale factors that affect survival of fish. (Ref. 540.)

There should be no measurable change in total commercial fish catches and landings that can be attributed to reduction in solids mass emission rates. Schools of anchovy and fish that feed on anchovy (mackerel, bonito, barracuda, yellowtail, queenfish) may occur less frequently near discharge sites off Palos Verdes and in Santa Monica Bay. Commercial fish landings will continue to demonstrate year-to-year variations depending on natural events unrelated to solids discharges. (Ref. 540.)

Discharge of sludge to the ocean under the Baseline Alternative should not adversely affect rare and/or endangered species.

It is generally unlikely that sludge discharges under the Baseline Alternative would result in widespread acute lethal effects to adult organisms since concentrations of toxic substances are generally low and soon diluted 150-fold after discharge.

Insufficient data are available to determine if there are adverse sublethal effects upon marine organisms (including juvenile and larval stages) associated with discharge of sludge under the Baseline Alternative.

Santa Monica Bay

Very little change is projected in emissions by the City of Los Angeles between 1978 and 1985. Baseline dewatering capacity is very nearly equal to the projected solids discharge to the ocean in 1985. A 23 percent increase in ocean discharge over 1977-78 levels is projected for the year 2000. Unlike the other LA/OMA operating agencies, sludge solids are discharged through a separate outfall system (7-mile outfall). Treated wastewater and effluent solids are discharged through the 5-mile outfall. In 1977-78, the amount of sludge solids discharged through the 7-mile outfall was about 2.5 times the amount of effluent solids discharged via the 5-mile outfall. This ratio is projected to be about 4 to 1 by the year 2000.

Even though separate discharge provides some differentiation between effects of effluent solids and sludge solids, there is apparently some overlap in the areas affected by the outfalls. (Ref. 559.)

No substantial change in the discharge from the 7-mile outfall is projected to occur under the Baseline Alternative. Since the region around the 7-mile outfall appears to have been stable for some time, conditions in the outfall region will probably change very little from the existing situation.

It is estimated that discharge from the 7-mile outfall has altered benthic community feeding patterns over a total area of about 48 to 54 sq. km. The most severe change has occured in a 3 sq. km. area at the end of the outfall, where the community is dominated by surface and subsurface deposit feeding organisms, and many "pollution indicator" species. Outside of this zone of greatest impact, feeding patterns are characterized by a large proportion of surface deposit feeding organisms, until background conditions (where suspension feeders dominate) are reached outside of the 48 to 54 sq. km. area. (Ref. 540, 559.)

Increased biomass and decreased species diversity of the benthic infauna are expected to continue. SCCWRP estimates that an excess standing crop (the wet weight of macrobenthic invertebrates in excess of normal background conditions) is confined to an area under 11 sq. km. (Ref. 540.)

Any change in the abundance of bottom fish near the 7-mile outfall will likely be masked by natural variations.

Offshore monitoring of Santa Monica Bay waters at various depths up to 42 meters has shown little or no influence of the 7-mile outfall on the water column bacteria. With minor changes projected in the discharge characteristics, the 7-mile outfall is expected to have little effect on the nearshore and beach bacteria counts. (Ref. 540.) It should be noted that during winter and early spring months, when the thermocline is absent, there is relatively free exchange of deeper waters with the surface.

With the exception of silver, only second order changes in the degree of trace metal contamination of sediments is expected in the vicinity of the 7-mile outfall. Because only minor changes in metal emissions are predicted for the 7-mile outfall under this alternative, levels of trace metals in bottom sediments and organisms around the 7-mile outfall are not expected to change significantly.

The SCCWRP 1971 survey of chlorinated hydrocarbons in the bottom sediments around the terminus of the 7-mile outfall revealed a maximum concentration of total DDT of 2 mg/dry kg. Tissue concentrations in organisms collected in the vicinity of this outfall are higher than elsewhere in Santa Monica Bay. The maximum PCB concentration in the 7-mile zone in 1971 was 12 mg/dry kg. Although PCB emissions from the 7-mile outfall have decreased by an order of magnitude since the early 1970s, there has been no clear decrease in PCB contamination of surficial sediments. (Ref. 540.) Similarly, over a three-year interval, there were only second order changes in PCB levels in muscle tissue of Dover sole from the area of the 7-mile outfall. No significant changes in PCB emissions are projected to occur under the Baseline Alternative. These facts suggest that PCB levels would decrease only very gradually in the benthic environment near the 7-mile outfall. (Ref. 540.)

Thus, it is unlikely that prevalence of fin erosion in the vicinity of the 7-mile outfall will change under the Baseline Alternative. SCCWRP has reported a 14 percent incidence at one location at the terminus of the 7-mile outfall.

Since increases in tissue burdens of chlorinated hydrocarbons are not likely to change, incidence of liver anomalies is not likely to be altered under the Baseline Alternative.

It appears likely that some of the larger sludge particles which settle near the end of the outfall would be transported down the Santa Monica Canyon, presumably to the floor of the Santa Monica-San Pedro Basin. However, most of the particles would be transported with the plume and be dispersed by ocean currents. (Ref. 539.)

There is no evidence that the sludge that has accumulated at the end of the 7-mile outfall is moving in mass towards the shoreline. (Ref. 539.)

SCCWRP has also projected reduction in the excess standing crop of benthic invertebrates associated with initiation of full secondary treatment of wastewaters discharged from the 5-mile outfall. Long-term reductions in abundance of selected trawl caught invertebrates and small reductions in abundance of Dover sole (Microstomus pacificus) and English sole (Parophrys vetulus) are also projected to result from improvements in the quality of the 5-mile outfall discharge. (Ref. 540.)

Palos Verdes Peninsula

Greatest reduction in sludge emissions is projected to occur in the Los Angeles County discharge. By 1985, sludge discharge to the ocean is projected to be about 13 percent of the 1977-78 levels but increase to about 30 percent in the Year 2000 as the result of projected increases in sludge volumes and assumed constant dewatering capacity. Since discharge of effluent solids and digested sludge solids occurs through a combined outfall, it is difficult to separate the effects of each solids component. In 1977-78, sludge solids accounted for about 60 percent of the total amount of solids discharged. This percentage is projected to decline to about 40 percent by 1985; then increase to about 60 percent by the year 2000, assuming no further dewatering facilities are installed. However, the volume of nonsludge solids would decrease drastically following implementation of full secondary treatment (i.e., those passing through the wastewater treatment process uncaptured).

Following are the predicted changes for the "area of greatest impact"--a zone extending 2 km NW from the terminus of the Whites Point 90-inch outfall, at 60 meters depth, following initiation of the Baseline Alternative:

Sediment concentrations of organic matter and trace metals are projected to initially decrease. In general, it is expected that such concentrations will decrease to levels between those which are currently characteristic of areas of intermediate distance from the outfall and areas in the vicinity of the Hyperion 5-mile outfall. Reductions in areal distribution of concentrations elevated above background is also projected to diminish substantially. Measurable hydrogen sulfide concentrations in surface sediments will be virtually, if not entirely, eliminated. (Ref. 506.)

DDT levels in sediments are also projected to initially decline to levels between those characteristic of areas of intermediate distance from the outfall and those in the vicinity of the Hyperion 5-mile outfall. However, it is expected that re-emergence of high surface concentrations of DDT will occur within about 5-10 years, as presently buried sediments are exposed. Such re-emergence is expected to be a "localized" phenomenon, limited to within several kilometers of the discharge site. A similar situation is projected for concentrations of chromium and lead, which are among the critical determinants of benthic biological community structure. (Ref. 506.)

Projections of PCB concentrations in sediments have not been made. However, a response similar to that projected for DDT would not be surprising since PCB levels in municipal discharges have been higher in the past than in recent years.

It is fairly clear that past discharges have created a reservoir of persistent pollutants among Palos Verdes sediments that will continue to disrupt certain characteristics of the biological community. Such disruptions will be related to an overabundant food supply in local sediments and continued presence of elevated concentrations of persistent toxicants such as heavy metals and chlorinated hydrocarbons. (Ref. 506.)

Changes in the local benthic community are expected to include compression, and perhaps disappearance, of the region characterized by low abundance and diversity as well as significant reductions in the area currently exhibiting biomass enhancement and diversity depression. Improvements in community structure are expected across the entire Palos Verdes shelf, with biological conditions in the region most heavily impacted approaching those currently observed in the vicinity of Hyperion Treatment Plant 5-mile sewage outfall. Enhancement of total biomass and depression of diversity are expected to characterize the zone of greatest outfall related impacts throughout the remainder of the twentieth century. (Ref. 506.)

Following is the scenario projected for the "area of greatest impact":

- Structural changes in the benthic community should include both a reduction in the dominance of annelids and an increase in molluscan biomass. The return of crustaceans and echinoderms to that area is not expected (before year 2000) due at least in part to the presence of excessive local concentrations of trace toxicants. Elimination of hydrogen sulfide-bearing sediments is predicted to follow implementation of secondary treatment. Recovery from related biological deficiencies is anticipated. The more diverse population which should develop will be more stable as the proportion of equilibrium species increases and opportunists decreases. (Ref. 506.)

- A series of transitory assemblages is expected to characterize the early stages of the benthic biological response until a less variable "equilibrium" condition is reached. Equilibrium community composition will depend on sediment and water column chemistry, biological interactions, and chance. The earliest stages in this successional sequence should be dominated by small, short-lived, opportunistic polychaetes. As their abundance declines, a secondary, a more diverse polychaete-dominated community will follow. Polychaete abundance and biomass will eventually give way to molluscan dominance. The number of species is expected to rise rapidly in the first few years; organism size and length of life cycle will gradually increase, as will community stability and diversity. Arthropods are expected to remain uncommon near the outfall until contaminants (such as DDT) decline in the top few centimeters of sediment. Echinoderms should remain rare at 60 meters, at least until Year 2000. Diversity is expected to stabilize early in the succession. Species from adjacent areas are expected to migrate toward the outfall area. Trophic diversity will increase, and the infaunal trophic index will rise to approximately 60. Increases after Year 2000 will be at a very slow rate. Deposit feeders will remain the dominant benthic feeding type, and suspension feeders will be poorly represented. Gradually, deeper foraging will occur within the sediments. Productivity is projected to increase in the immediate vicinity of the outfall but decrease in surrounding regions. (Ref. 506.)

- The net effect by Year 2000 will be of reduction in the excess benthic biomass on the shelf to 17 percent of estimated 1977 values. The area affected by excess standing crop will be 36 percent of the 1977 estimated area. The extent of the bottom in which infaunal trophic index values are less than 30 (an area characterized by subsurface deposit feeders) will decrease from 7 sq. km. to 0.5 sq. km. The area with index 30 to 60 (characterized by surface feeding and surface deposit feeding organisms) will be reduced from 105 sq. km. to 12 sq. km. (Ref. 506.)

The foregoing does not take into account unpredictable perturbations in physical oceanographic conditions (such as a 100-year storm) or biological events (e.g., reinvasion by a large dominant such as Listriolobus), both of which could change recovery rates of the benthos. (Ref. 506.)

Bioaccumulation of persistent organics and heavy metals in benthic animal tissues is expected to be less severe in the first years following implementation of the Baseline Alternative. The existing record indicates that surface sediment concentrations of metals and DDT (and animal tissue concentrations) have declined during the past decade. Although fishes appear not to concentrate most metals, they have bioaccumulated the chlorinated hyudrocarbons to a high degree. In general, accelerated reductions in sediment, invertebrate, and fish tissue levels are expected following implementation of adequate source control measures. (Ref. 506.) Reductions in trace metals in deposit and filter feeders (e.g., Dover sole, mussel, scallop, abalone) are also expected. (Ref. 540.)

Significant improvements in percent coverage and species diversity in the rocky subtidal community are expected. Reduced solids and organic emissions will be directly reflected in local burial rates, making available previously unused rocky substrate. Recovery of sessile organisms is expected along all coastal reaches where outfall-related effects are currently observed. Reduced solids loading will also encourage recruitment and growth of attached algal species at greater depths (reflecting light transmission improvements). Included among these species is *Macrocystis* (giant kelp), which in the distant past (predischarge) dominated the Palos Verdes rocky subtidal environment. The concentration of toxicants in surface sediment and floc would be substantially reduced in response to reduced solids emissions and enforcement of federal pretreatment regulations. Although it is not possible to estimate the predicted degree of recovery precisely, it is felt that under the Baseline Alternative, characteristics of the rocky subtidal community, including abundance, percent coverage, diversity, and structure, will lie within the range of those expected in similar, but unpolluted areas. A distant station (Palos Verdes Point) presently overlaps the range of values found at a control station off La Jolla. (Ref. 506.).

Increased abundance of certain species of demersal fish are expected following reductions in solids emissions. Populations of California tonguefish (*Symphurus atricauda*), Yellowchin sculpin (*Icelinus quadriseriatus*), and Pacific sanddab (*Citharichthys sordidus*) should increase offshore of Palos Verdes. Relative abundances of speckled sanddabs (*Citharichthys stigmaeus*) should also increase in shallower waters. Re-emergence of DDT in sediments may alter these projected changes. A major reduction (at least 90 percent) in abundance of Dover sole (*Microstomus pacificus*) is expected. Areas further from the outfall are expected to recover more rapidly than the area of greatest impact, because contaminant loads are lighter, and because organic enrichment appears to be a major factor affecting community structure. (Ref. 506.)

Problems of elevated disease incidence among demersal fishes may persist, however, firm predictions cannot be made since causes of fin erosion and liver anomalies remain obscure. Although the fin erosion syndrome is clearly still being initiated at Palos Verdes (the disease is still prevalent in recently settled individuals), since 1972 there has been an apparent decrease in the frequency of diseased specimens taken from nine standard monitoring stations. (Ref. 506.) Fin erosion appears to result from exposure of susceptible species to sediments contaminated with chemical wastes (Ref. 546.) In view of the expected "localized" re-emergence of contamianted sediments, it would appear likely that fin erosion will continue to be observed in such areas and improvement will be related to the rate of improvement of sediment conditions.

Historic decreases in coliform concentrations in shellfish have been observed and reportedly related, in part, to decreases in solids emissions. In view of the reduced solids discharge and improved treatment under the Baseline Alternative, levels of coliform in shellfish should be in consistent compliance with recommended limits and achieved with minimal need for chlorination.

Reduced chlorination would result in reduced formation of lower molecular weight chlorinated organics (which result from the interaction of chlorine with discharged material). At present, chlorination is practiced only during winter months, and therefore the benefits associated with reduced chlorination would be observed only at that time.

Coliform standards for bathing waters are currently being achieved at established monitoring stations and should continue to be met under the Baseline Alternative.

In the past, trace quanitities of grease of sewage origin (small, 1-3 mm white clumps) have been observed frequently at shore stations. Frequency of grease observations decreased significantly following improved solids handling in 1976. In view of the reduced solids emissions and improved treatment under the Baseline Alternative, observations of grease and other floatables should be essentially eliminated. (Ref. 506.)

Surface discoloration and odors have been recorded when the wastewater plume "boils." This condition usually occurs in winter when there is no strong thermocline. Without a density barrier, the discharge plume rises to the surface, causing a visible boil in a limited area over the discharge point (approximately two miles offshore). Since this phenomenon is basically related to oceanographic conditions, it is expected to continue under the Baseline Alternative. However, a decrease in strength of odors and discoloration is expected. (Ref. 506.).

Obviously, substantial changes in the marine biotic community are expected to occur under the Baseline Alternative. Implications associated with such changes or conditions include (1) reduced concern for consumption of fish and organisms taken from the outfall area because of accumulations of halogenated hydrocarbons and certain trace metals, and (2) reduced concern for pathogenic organisms in shellfish, and for grease and floatables of sewage origin.

Orange County

Orange County is not projected to discharge significant volumes of sludge solids to the ocean until the 1990s. Until then, effluent solids would constitute the total solids discharge. By the year 2000, sludge solids are projected to account for about 70 percent of the total solids discharged, assuming a constant sludge dewatering capacity. Effluent solids and sludge solids would be discharged through a combined outfall system. Thus, it is difficult to separate effects of each component of the solids emitted.

Under the Baseline Alternative, maximum organic carbon concentrations are expected to be at levels slightly above background. Increases in solids discharge between 1985 and 2000 would likely result in larger concentrations of organic matter in sediments around the outfall, perhaps as much as current levels.

SCCWRP analyses of monitoring data collected by Orange County Sanitation Districts (OCSD) suggest that concentrations of trace metals in sediments within a 10.6 square kilometer zone around the outfall diffuser have reached approximate equilibrium. It appears that reductions in sediment metals concentrations should parallel historical patterns of change in PCB sediment concentrations and decrease rapidly. New equilibrium levels are therefore expected to be achieved within approximately 1 year after onset of the Baseline Alternative. (Ref. 540.)

SCCWRP studies have shown order of magnitude reductions in the amount of PCB discharged by OCSD beginning in 1972. DDT inputs have been negligible. Monitoring data indicate that median PCB concentrations in surficial sediments near the OCSD outfall have decreased rapidly since 1974, with a half-time on the order of 1 year. Values reported in 1977 generally were below 0.1 mg/l. Substantial reductions in PCB emissions are projected to occur as a result of improved wastewater treatment. However, emissions of PCB would be expected to increase between 1985 and 2000 with the addition of digested sludge solids to the effluent stream. It seems reasonable to expect that PCB sediment concentrations would continue to decline until digested sludge solids are discharged, when such decline would be halted or possibly reversed.

Changes in trace metals and PCB concentrations in marine organisms may be related to changes in sediment concentrations and in emission rates. Average concentrations of PCB in muscle tissue of speckled sanddab have decreased at a rate similar to reductions in sediment concentrations; by the end of 1976 tissue concentrations had fallen below 0.1 mg/wet kg.

The excess standing crop of benthic infauna will be reduced by about 80 percent by year 2000. A slight decline in abundance of bottom fish and large invertebrates is projected near the outfall terminus.

It is clear that effects of past practices have been much less extensive in the vicinity of the Orange County disharge than at other outfalls. The shorter operating history and lower solids emissions and flow rates are partially accountable for this difference.

Benthic effects associated with the outfall are added to impacts which result from large scale urban influences in San Pedro Bay. It is difficult, therefore, to describe effects in terms of changes in benthic feeding patterns. It seems reasonable, however, to conclude that alterations now associated with the outfall will diminish substantially. Such a decline may, however, be halted or possibly reversed as digested sludge solids are added to the effluent discharge.

Implications associated with this discharge center principally around concern for PCB accumulations. Reductions in discharge and sediment concentrations are, however, partially offset by projected increases associated with addition of digested sludge.

Deep Ocean Outfall (4S1)

Information on potential impacts of this project has been developed through reconnaissance level study and mathematical modelling. The focus of this study has been largely on effects upon dissolved oxygen sulfide concentrations in sediments, and alteration of trace metal concentrations in the water column. (Ref. 507.)

After discharge from the submarine outfalls at depths of about 300-400 meters, the freshwater-sludge mixture would be expected to rise until it reaches a level of neutral buoyancy--about 50 meters above the discharge pipe. At this point, the sludge-seawater mixture would spread horizontally and particles would start to settle out on sediments below. Bacterial decomposition of the solids would remove oxygen from an already oxygen-poor environment and release trace metals and trace organics which are associated with the particles.

Modelling studies by California Institute of Technology scientists indicate that deposition of particulate matter would occur over a fairly extensive area within the Santa Monica-San Pedro Basin. A few percent of the particles would be expected to settle out near the outfall terminus (within a kilometer) while the bulk of the sludge particles reaching the sediments would be well dispersed over an oblong shaped region oriented along the bottom contours near the ends of the outfalls. While it is projected that no more than 6 percent of the sludge particles would reach the bottom sediments, sedimentation rate of organics would be doubled over an area of about 120 sq. km Generation of hydrogen sulfide is likely in areas of highest deposition. The balance of the sludge solids are projected to be oxidized within the basin (59 percent) or transported out of the basin by current action prior to deposition.

These modelling studies further indicate that while dissolved oxygen concentrations would be depressed below levels in the water columm, dissolved oxygen concentrations in bottom sediments of the basins should not be depressed below 4 micromoles, the minimum level which would permit organisms to function aerobically.

Midwater fauna live by filtering particulate matter out of the water, scavenging, or predation. Sludge disposal might affect these animals by mixing with their normal food to form a deleterious diet, by interferring with the chemical cues that they need to find their food, or by poisoning from trace metals or trace organics. Modelling indicates that soluble trace metal concentrations allowable under the California State Ocean Plan should not be exceeded. To the extent that these standards encompass toxic effects upon mid-water organisms, increased trace metals concentrations should not harm the mid-water population.

Modelling results also indicate that particulate organic carbon concentrations in the water column would be increased as much as one order of magnitude over background concentrations. Effects of this change on zooplankton are unknown.

Benthic fauna would be impacted by the increasing sedimentation of organic matter. Due to the very low oxygen concentration in the deep sediments, it is questionable whether predictions can be extrapolated from monitoring of existing discharges. Existing solids discharge has produced an increase in benthic biomass and a decrease in species diversity. Knowledge of benthic community composition in the Santa Monica-San Pedro Basin is limited. (Ref. 558.)

As a general observation, outfalls would be located at depth (300 or more meters) and substantial distance offshore. Such areas are generally considered to be lower in biological activity than nearshore coastal waters or waters in the euphotic zone of the ocean. Also, a greater physical discontinuity exists between a 300 meter deep basin outfall and the shore than between a shelf outfall and the shore. The prospect for transport of material toward shore by upwelling has not been examined, but the steep wall of the slope should tend to form a natural barrier against shoreward transport.

Information on the effects of deepwater discharge on the marine environment are scanty, and a great deal of background data must be gathered before adequate predictions of impacts may be made. Such studies were beyond the scope of the current analysis and have been recommended by SCCWRP and the California Institute of Technology, the principal investigators of this alternative for LA/OMA Project. (Ref. 507).

Sludge quality and disposal site would determine the extent and types of impacts. Among the obvious areas in which data are scarce and essential for defining the environmental responses are:

1. Physical/chemical properties of sludge. Settling velocity experiments must be conducted in order to determine dispersion characteristics of different sludge types. For example, waste activated sludge is believed to be approximately one-third lighter than primary sludge. Problems related to thickening of settled waste activated sludge have not yet been resolved. Lower current strengths would be adequate for resuspension. Biotic impacts would differ with the flocculence of the material. At Hyperion, the plume of unthickened sludge is believed to rise approximately 50 meters and then spread horizontally and diffuse in ocean turbulence. Dispersal over a wide area may reduce severe benthic impacts to a relatively small area.

2. Current measurements are needed inshore, offshore, and at several water column levels, particularly at depths of discharge. These are necessary for studies of flow patterns, sludge/seawater mixing rates, and predictions of areal extent of particulate deposition.

3. Other needed information on sludge types includes mass emission rates of solids, and concentrations of total organic carbon and trace contaminants.

Toxicants and percent of refractory organic carbon may vary with sludge type. Metal mobilization requires further study. Oxidation levels will be critical. If waste activated sludges are digested, trace metal release in highly oxidized or biologically available (and thus increasingly toxic) forms appears less likely. Also, very low oxygen levels expected at depths of 300+ meters are not conducive to metals release from bound forms. Nevertheless, stringent pretreatment standards should be enforced in order to guarantee feasibly minimal potential detrimental effects.

4. The effects of timing of discharge (lower continuous versus intermittent large discharges) need to be explored. Intermittent discharges may minimize cumulative effects. Optimally, the degree of organic deposition which could be assimilated by the benthic environment should be estimated.

5. The distribution, abundance, and physiology of organisms, both in the water column and in the sediments at these depths are not well studied. Los Angeles County Sanitation Districts has sampled across the Palos Verdes shelf sediments, at 300 meters depth, with a Shipek grab sampler on a dozen occasions. Infaunal abundance and biomass at 60 meters is three to four times higher than at 300 meters. Reduced oxygen levels may be critical at these depths, but appear to be considerably less significant at 300 meters than in deeper sediments. The potential for displacement of ecologically important midwater or benthic organisms by slight changes in water quality needs to be explored.

Thus techniques are being developed for predicting the spatial and temporal extent of many of the problems associated with ocean disposal of solids. All modelling and predictive tools require extensive studies in potential discharge sites. In the future it should be possible to project the quantity and quality of solids which can be safely disposed in deeper waters, the fate of sludge particles, and the extent of potential detrimental impacts. More information is needed to identify which trace toxicants are in greatest need of control, and at what levels. Such contamination should be reduced to lowest levels feasible in order to minimize present and future impacts.

Barge Disposal (4R1)

Barge disposal of sludge is a technique practiced primarily on the East Coast of the United States. Two methods have been used -- discharge through a bottom opening hopper and pumped discharge through a pipeline suspended beneath or behind the barge. This project would employ the pumped discharge method to inject sludge into the ocean at depths of 100-150 feet. Information on potential impacts is lacking and generally limited to conclusions that can be drawn from the experience on the East Coast.

Discharge of sludge at depths indicated would be below the thermocline and surface contamination should be avoided. Depth of discharge appears to be sufficient to accommodate seasonal fluctuations provided the discharge occurs within the Southern California Countercurrent, where the depth of the thermocline is generally on the order of 10 meters. (Ref. 551). Failure to discharge below the thermocline would result in surface contamination and probable discoloration of the ocean at the dump site.

Considering the water depths (500-900 meters) and the wide range of settling velocities of the sludge particles, sludge solids are likely to remain in suspension for relatively long periods. Heavier particles which would tend to settle out faster, would likely be affected by short-term currents. Sludge particles with lower settling velocities should oscillate in the water column through action of short-term currents, but will ultimately be dispersed by long-term currents such as density driven coastal currents, and ocean turbulence. (Ref. 552.)

Organic constituents of the sludge are subject to oxidation and scavenging in the water column. While reduction in dissolved oxygen will occur in the immediate area of the discharge, impact should not be severe because of generally high background concentrations. Chromium, copper, lead and zinc are expected to accumulate in bottom sediments, but cadmium is not expected to do so since it rapidly dissolves in the water column. (Ref. 505, 552).

Large concentrations of potentially toxic particles would be placed nearer the surface in the more productive zone of the ocean. Filter feeders may be susceptible to changes in phytoplankton. Since the food web is likely to be more structured in these deeper waters, because of limited food sources, enhanced potential for bio-accumulation of toxicants may result.

Barge disposal would potentially make the entire Southern California Bight the site for discharge. While cumulative effects should be minimal because of dispersal over large areas, localized nutrient concentrations would occur. Euphotic depth could potentially be affected, but would only occur in a small area of the Bight at any one time. Phytoplankton productivity might be enhanced; however, there is disagreement as to the reality of this potential.

As was the case with the Deep Outfalls Project, data are not available to permit more precise projections of impacts. Of particular concern are mid-water effects and the fate of the particles after discharge. Such studies were beyond the scope of the analysis.

MITIGATION MEASURES

Improvements in industrial source control efforts can be expected to result from the stimulus provided by requirements of the Federal Water Pollution Control

Act. It is clear that industrial source control programs are a key factor in estimating and reducing the impacts of sludge on marine biota.

LA/OMA Project studies indicate that substantial reductions in the levels of trace metals in sludges are apparently achievable. Such reductions should further reduce adverse impacts associated with trace metals. Source control efforts for new industrial additions of halogenated hydrocarbons should be reasonably effective in controlling such substances, although there appears to be a low level of continuing discharge of DDT and PCB.

Effectiveness of industrial source control programs for precluding discharge of undesirable substances into the sewer system may be limited. Without economic (from the viewpoint of the waste disposer) alternatives for disposal of residuals produced by pretreatment, the possibility of unauthorized discharges exists. Additionally, as industrial contributions are reduced, uncontrollable (e.g., domestic, unknown industrial) sources account for a larger share of the toxicants discharged. Prospects for immediate control of such sources are remote and largely dependent upon substantial changes in product usage by society.

The addition of sludge will alter the marine communities since it can be expected with adequate pretreatment, plant design and management, to increase the fertility of the nearshore waters, and result in an increase in the abundance of flora and fauna. (Ref. 803.).

All three outfall systems, discharge to a soft substrate bottom. Care would need to be taken to insure that build-up of organics is not sufficient to cause anoxic conditions on the bottom. As long as the marine system is not overloaded and adequate source control is in effect, the impacts need not be detrimental to the organisms. (Ref. 564).

At the Palos Verdes site, hard rocky substrate also exists in proximity to the outfall terminus. Finely suspended sludge particles and associated chemical contaminants have been shown to adversely affect the marine biota dependent upon this substrate. Close control of solids discharges is warranted in this ecologically sensitive area. The application for waiver of secondary treatment requirements submitted by Los Angeles County Sanitation Districts indicates that partial secondary treatment of wastewaters, which removes lower particulates mass, could partially mitigate effects associated with re-emergence of contaminated sediments. The application also indicates that partial secondary treatment should not significantly interfere with recovery of kelp forests off Palos Verdes (12 percent habitat loss is projected).

Develoment of mitigation measures for the Deep Ocean and Barge Disposal Projects must await completion of detailed studies required to evaluate impacts resulting from such projects.

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EVALUATION OF CULTURAL RESOURCES

INTRODUCTION ●

APPENDIX B4

EVALUATION OF CULTURAL RESOURCES

The Evaluation of Cultural Resources at the City of Los Angeles Hyperion Water Pollution Control Facilities, County of Los Angeles Joint Water Pollution Control Plant, and Orange County Sanitation District Proposed Round Canyon Site was performed for the LA/OMA Regional Wastewater Solids Management Program in preparation of the DEIS/DEIR. It was prepared by E. Gary Stickel, Ph.D. of Environmental Research Archaeologists: A Scientific Consortium, Los Angeles for: Daniel, Mann, Johnson, & Mandenhall, also of Los Angeles, and submitted August, 1979.

EVALUATION OF CULTURAL RESOURCES

at the

City of Los Angeles Hyperion Water Pollution Control Facilities,
County of Los Angeles Joint Water Pollution Control Plant, and
Orange County Sanitation District Proposed Round Canyon Site

for the

LA/OMA REGIONAL WASTEWATER SOLIDS MANAGEMENT PROGRAM
DEIS/DEIR

INTRODUCTION

The following report prepared by Environmental Research Archaeologists (ERA) fulfills the requirements of work established by Daniel, Mann, Johnson, & Mendenhall (DMJM). The objective of the work was to prepare a cultural resources management (CRM) report on three subject properties included in the Proposed Regional Wastewater Solids Management Program developed by the Los Angeles/Orange County Metropolitan Area (LA/OMA) Project.

The subject properties are within (1) the City of Los Angeles Water Pollution Control Facilities (Hyperion) located at 1200 Vista Del Mar, Los Angeles, California; (2) the County of Los Angeles Joint Water Pollution Control Plant (JWPCP) located at 24501 South Figueroa, Carson, California; and (3) the Orange County Sanitation District (OCSD) proposed Round Canyon site located in the Lomas de Santiago Hills approximately one kilometer northeast of the present El Toro Marine Corps Air Station. The subject properties were identified for CRM by ERA after a review of the literature search conducted by DMJM for the environmental evaluation of sludge management alternatives (cf. DMJM, 1979).

Specific tasks included in the investigation of each subject property were:

- Selected on-foot surface survey to (1) locate previously recorded or suspected sites, and (2) identify any new sites.
- Evaluation of the significance of the cultural resources located and identified during the field survey.
- Determination of the possible disturbance or destruction of the cultural resources during the proposed construction.
- Recommendation of further cultural resources management procedures appropriate to the significance/potential damage of each cultural resources.

The results of the investigation established that there were no cultural resources identified within the subject property at the Hyperion Treatment Plant. Cultural resources were identified within the subject properties at the Joint Water Pollution Control Plant and at Round Canyon. The latter will be recommended for inclusion in the National Register of Historic Places.

Personnel involved in the investigation were:

- Principal Investigator

  E. Gary Stickel, Ph.D., who is Director of Research for ERA, holds an A.A., B.A., M.A. and Ph.D. (University of California at Los Angeles, 1974) in Anthropology with a specialization in Archaeology.

  He is certified to be P.I. for archaeological investigations in California by the Society of Professional Archaeologists (SOPA). He presently serves as the SOPA representative to the United Nations Committee on the Preservation of the Oceans. He has been involved in California Archaeology since 1965 and has authored numerous publications on the subject. Specialties include New World Archaeology, California Archaeology, Chromometric Dating Techniques, Underwater Archaeology, and Archaeological Methods and Theory. He currently is conducting joint research at the Radiocarbon Dating (Isotope) Laboratory at UCLA, where he also teaches a variety of archaeological extension courses for the Department of Humanities and Social Sciences.

- Research Associate

  Mr. Roderick S. Brown, who is Director of Field Operations since 1978, has a B.A. in Anthropology (California State University, Long Beach, 1975). He is experienced in all aspects of field recordation procedures and techniques, participating in and directing a number of CRM projects in California and throughout the country. He is particularly familiar with the archaeology of Los Angeles and Orange Counties.

A description of the archaeological investigations of each subject property and recommendations for future CRM work are presented in the following.

1.0 CITY OF LOS ANGELES WATER POLLUTION CONTROL FACILITIES (HYPERION)

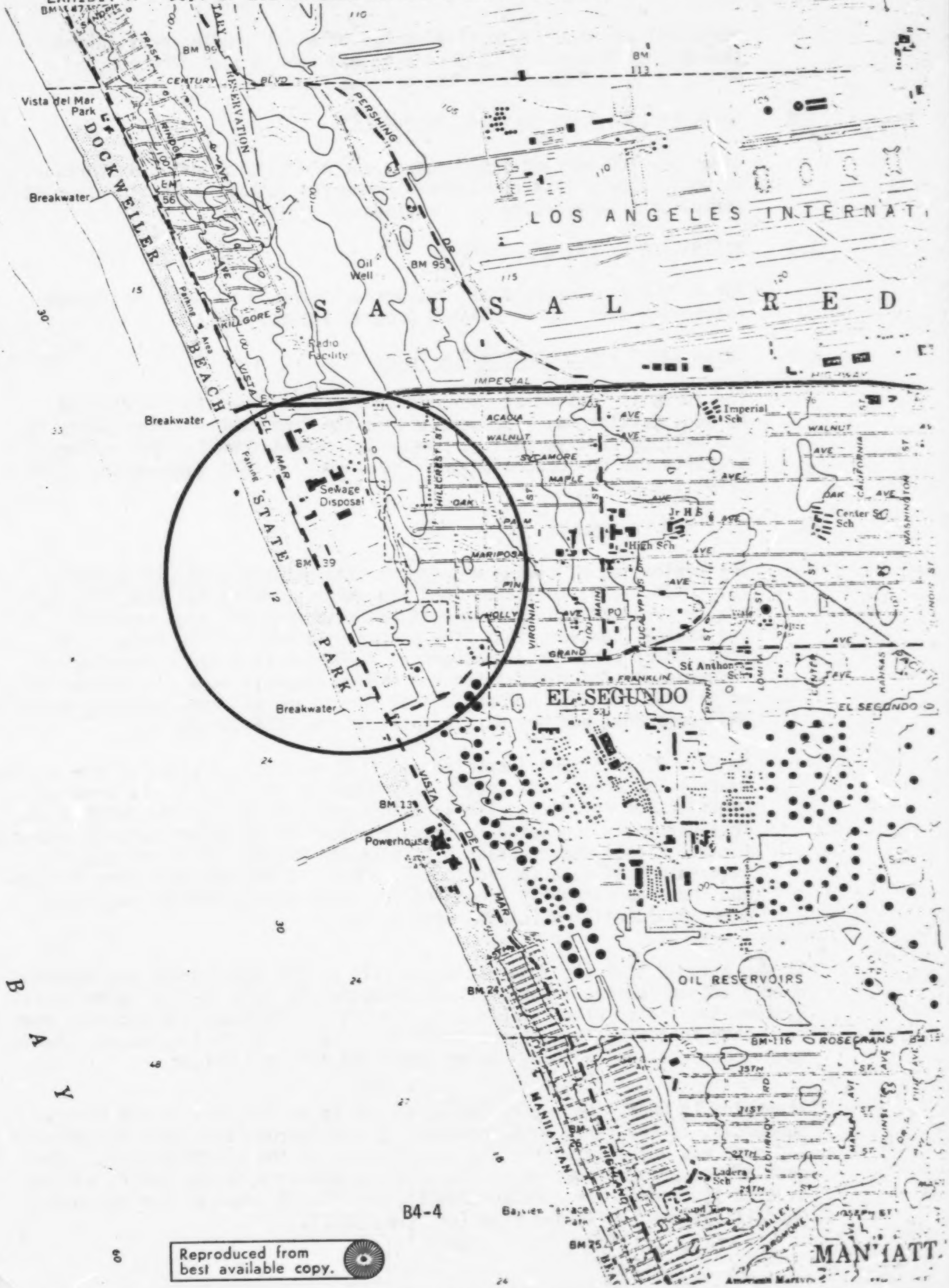
The Hyperion facility is located just south of the Los Angeles International Airport at 1200 Vista Del Mar, Los Angeles, California, approximately 300 meters from the marine coastal waters of Santa Monica Bay. The subject property can be found on the "Venice" 7.5 minutes USGS quadrangle. (See Exhibit A.)

1.1 SITE SURVEY RESULTS

The evaluation of sludge management alternatives by DMJM (cf. DMJM, 1979) indicated that the area had not been surveyed and that no cultural resources (e.g., prehistoric archaeological sites) had been recorded to date.

On July 3, 1979, ERA inspected all portions (100 percent) of the approximately five (5) acres that potentially would be affected by the proposed construction at Hyperion. All areas were found to be planted with grass or similar introduced vegetation. Senior plant

EXHIBIT A - CITY OF LOS ANGELES HYPERION WATER POLLUTION CONTROL FACILITIES



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personnel allowed ERA to examine the original grading maps, which showed that the entire subject area had been graded from approximately 3 to 6 meters below the original surface.

1.2 POSSIBLE LOSSES OF CULTURAL RESOURCES

Given the 100 percent field survey and the data on prior disturbances, it would appear that no cultural resources (either prehistoric or historic) will be affected by the proposed project.

1.3 MITIGATION OF ADVERSE IMPACTS

Due to the lack of cultural resources, there is no need to include future CRM work in the planned program at Hyperion.

2.0 JOINT WATER POLLUTION CONTROL PLANT

The JWPCP is located at 24501 South Figuero Street in the City of Carson, California. Included within the treatment plant property is the Kellogg Supply, Inc., a commercial establishment. The subject property can be located on the "Torrance" 7.5 USGS quadrangle. (See Exhibit B.)

2.1 SITE SURVEY RESULTS

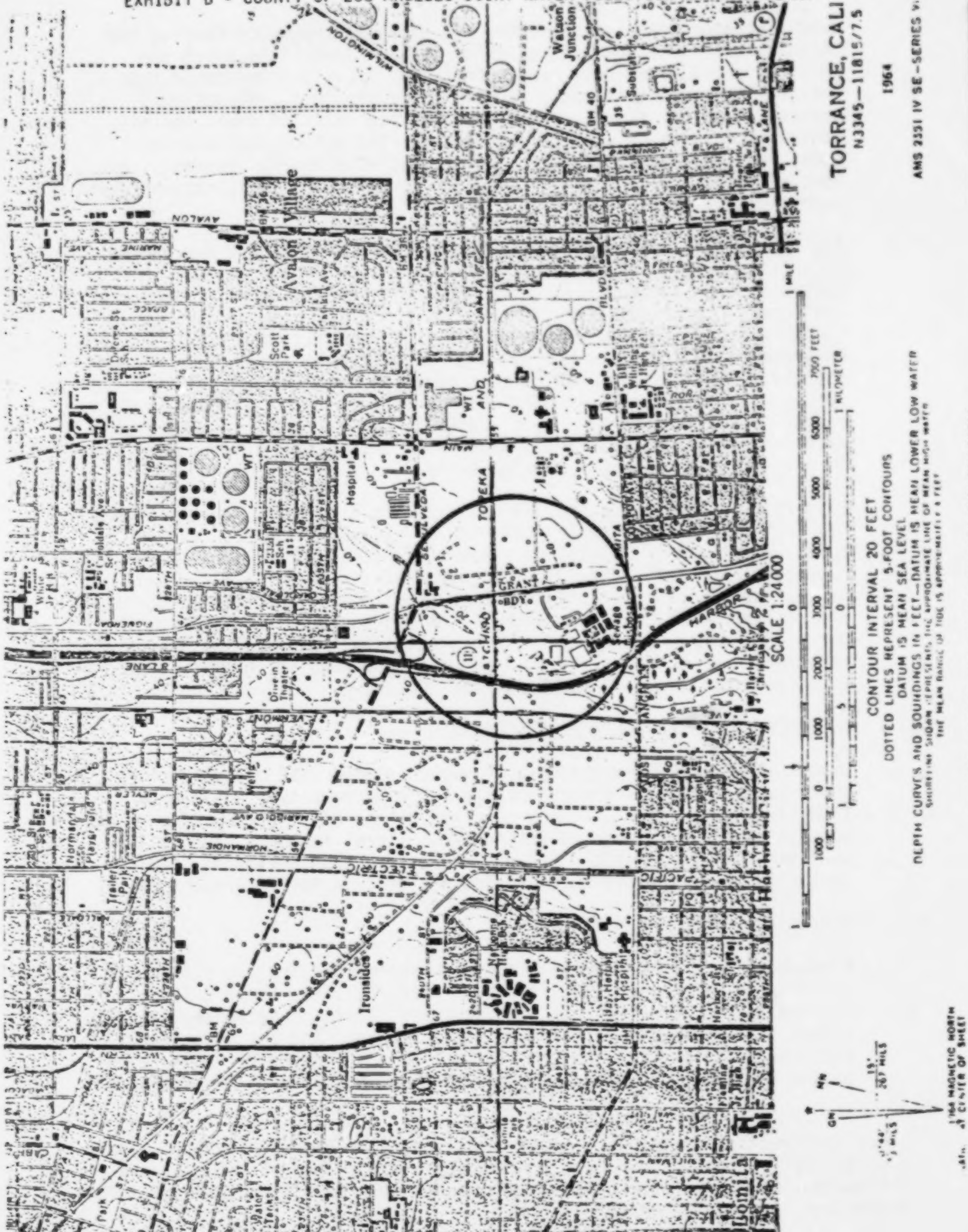
The evaluation of sludge management alternatives prepared by DMJM (cf. DMJM, 1979) indicated that the JWPCP property had been only partially surveyed and that no cultural resources had been recorded. It was stated, however, that "the property is part of the Harbor Lake Area, which contains a substantial number of recorded archaeological resources." The sources for the DMJM statements were (1) information on file at the UCLA Archaeological Survey and (2) conversations between DMJM personnel and Mr. Martin Rosen of the UCLA Survey.[1/]

On July 3, 1979, ERA inspected all (100 percent) portions of the approximately 150 acres that potentially would be affected by the proposed construction at JWPCP. The area included portions of the JWPCP property currently scheduled for construction and an adjoining area proposed for additional construction by the LA/OMA Project.[2/] A prehistoric archaeological site (approximately 500 x 500 meters) extending throughout the area currently scheduled for construction and the adjoining area was identified (LA/OMA Site No. 1).

[1/] It was assumed that the information on file at the UCLA Survey was obtained during archaeological investigations conducted in 1975 for the Joint Outfall Systems Facilities Plan EIS/EIR (cf. EPA, 1977), although the document does not state specifically that the JWPCP property was in fact surveyed. Subsequent conversations with Mr. Rosen confirmed this assumption.

[2/] According to DMJM, the entire 150 acres was to be included in the survey. Subsequent to the field work, however, it was learned that only the adjoining area was actually within the jurisdiction of the LA/OMA Project. The rest of the property was under the sole jurisdiction of the JWPCP, who considered it cleared for construction by the EIS/EIR prepared for the Joint Outfall Systems Facilities Plan (cf. EPA, 1977).

EXHIBIT B - COUNTY OF LOS ANGELES JOINT WATER POLLUTION CONTROL PLANT



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Human introduced ecofacts in the form of shell fragments denoted the LA/OMA Site No. 1. The character of the soil matrix in which the shell occurred, the grain size, condition, etc., all indicated that the shell was not introduced by natural causes (e.g., elevational changes, erosion, floods, etc.), but had been part of shell exploitation activities or similar pursuits carried out by prehistoric human inhabitants of the area. No manufactured tools, ornaments, etc., however, were observed on the surface (no subsurface explorations were undertaken).

The character of the LA/OMA site No. 1 is not unusual for the general area (cf. Stickel, 1976). For example, a major excavation was conducted at two previously recorded archaeological sites in the greater environs of the study area (CA-LAn-271, and 275). These sites contained economic species of shell (i.e., nonrandomly selected from the environment as a food source) similar to those recovered at the LA/OMA site No. 1 (cf. Stickel, 1976). In addition, significant cultural resources are to be expected in this area, since it has the highest number of prehistoric sites (cf. Bucknam, 1974) and the highest number of ethnohistoric sites (cf. Johnson, 1962 and Heizer, 1968) of any area in the entire greater Los Angeles Basin.

By surface inspection alone, it was impossible to determine the potential artifactual yield of LA/OMA site No. 1, or whether cultural features and/or human burials were present. Although the general area had been developed for a freeway, railroad tracks, and a flood control channel, as well as the existing treatment facilities, the area in question did not appear to have been significantly disturbed. Conflicting reports on grading, construction, etc., activity were received from JWPCP personnel. In addition, records of past construction, grading plans, etc., were not available at JWPCP for review.

2.2 POSSIBLE LOSSES OF CULTURAL RESOURCES

Based upon surface indications, it was concluded that a prehistoric shell midden site was present at the subject property. Based upon the literature cited above, it was considered possible that the site might contain other data, such as artifacts, cultural features, and Native American burials. Further CRM procedures are thus indicated in order to verify this potential and provide a direction for future action.

2.3 MITIGATION OF ADVERSE IMPACTS

A standard test phase investigation is recommended for the subject property (cf. Schiffer, Sullivan, and Klinger, 1978; Butler, 1973; Bucknam, 1974; and Chartkoff and Chartkoff, 1972) to determine (1) the actual size and depth of the site, (2) the range and age of potential cultural data, and (3) the significance of the findings.1/ The recommended test phase investigation was reviewed by the UCLA Archaeological

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1/Since construction on the portion of the property solely within the jurisdiction of JWPCP appeared imminent, a preliminary report and recommendations for implementation of the test phase investigation were submitted to JWPCP. The matter was handled independent of ERA.

Survey with the following conclusion: "The recommended site investigation procedures are standard: intensive surface examination (collection), augering, test pitting; these tests are the only manner in which you can determine the nature of the deposit" (cf. Rosen, 1979).

In order to ensure (1) that a representative sample of data will be recovered and (2) that the total number of potential artifacts and/or ecofacts may be estimated for furture CRM mitigation, it is recommended that all exploratory units (test pits and auger holes) be determined statistically by means of a random sampling program (cf. Redman, 1973 and Read, 1978). In order to ensure the professional quality of the CRM work, it is further recommended that the Principal Investigator (P.I.) be selected from the list of qualified professionals prepared by the Society of Professional Archaeologists (SOPA).

3.0 ORANGE COUNTY SANITATION DISTRICT PROPOSED ROUND CANYON SITE

The proposed Round Canyon site consists of approximately 640 acres confined within a northeast/southwest oriented rectangle. The rectangle is located approximately one kilometer northeast of the El Toro Marine Corps Air Station. The northwestern portion of the rectangle is within Round Canyon, while the southeastern (long axis) boundary is formed by Agua Chinon Wash. The subject property can be found on the "El Toro" 7.5 minute USGS quadrangle. (See Exhibit C.)

3.1 SITE SURVEY RESULTS

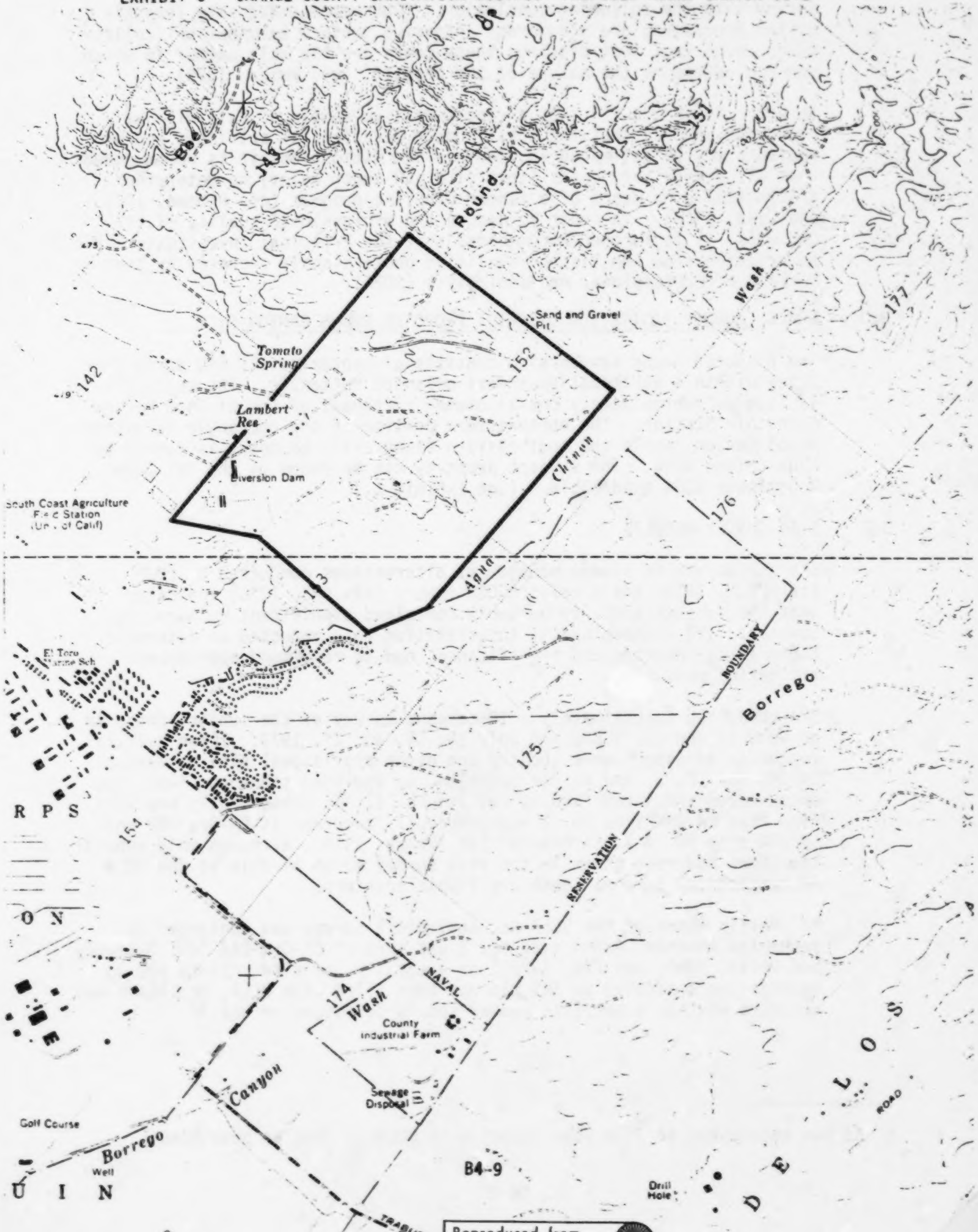
The evaluation of sludge management alternatives conducted by DMJM (cf. DMJM, 1979) and a related CRM report (cf. SRS, 1978) indicated that the subject property probably contained significant cultural resources. The archaeological investigation was conducted to determine their exact location and significance, and to recommend appropriate mitigation measures.

ERA conducted approximately a 10-percent survey of the subject property on June 12 and 13, 1979, and July 18, 24, and 27, 1979. Three cultural resources of import were located and given provisional site numbers of LA/OMA Nos. 2, 3, and 4. In addition, an isolated stone tool was also encountered and identified as Isolate No. 1. It subsequently was verified that LA/OMA site No. 2 was previously recorded as CA-Ora-762 and LA/OMA site No. 4 as CA-Ora-761 (cf. Mabry, 1978), although only general locations had been given in the site survey forms on file at the UCLA Archaeological Survey. Both are lithic scatters.

Mr. Martin Rosen of the UCLA Archaeological Survey was contacted to determine whether LA/OMA site No. 3 was part of CA-Ora-244 (cf. McKinney and Smith, 1965; and SRS, 1978), or a totally new site. Since the investigation conducted by SRS had not been filed with UCLA, Mr. Rosen was not sure whether a new site number should be issued or not.1/

1/SRS has been asked to file this report with UCLA as soon as possible.

EXHIBIT C - ORANGE COUNTY SANITATION DISTRICT PROPOSED ROUND CANYON SITE



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3.1.1 LA/OMA Site No. 2 (CA-Ora-762)

As described by Mabry (1978), LA/OMA Site No. 2 is a "large, sparse surface distribution of lithics--possibly subsurface" . . . . including "ground stone,cores, many cobbles." ERA made similar observations and also identified manos and mano fragments, a scraper, a pulping plane, and waste flakes. The site may have some depth, but probably is a surface site.

3.1.2 LA/OMA Site No. 3 (CA-Ora-244?)

As described by McKinney and Smith (1965), CA-Ora-244 contained "leaf points, notched points of chert and quartz, schist bowl sections, broken and reworked manos, hammerstones, metates, clipping waste of quartz, granite, jasper, basalt, and desert petrified palm, yellow, red, and blue Jasper." They also noted that the site was formerly recorded as an "Oak Grove" site by W. Strandt (cf. Smith 1965), but to them, it appeared of more recent age.

The site that ERA identified as LA/OMA site No. 3 had high, dense grass cover--at the time of the survey. Nevertheless, an extremely dense distribution of manos,mortar fragments, metate fragments, hammerstones, scrapers, choppers, cores, and lithic debitage were observed. Ecofacts included some shell (*Chione* spp.) fragments and some possibly naturally occurring bone fragments.

3.1.3 LA/OMA Site No. 4 (CA-Ora-761)

As described by Mabry (1978), LA/OMA Site No. 4 is a "surface lithic scatter--possible shallow subsurface--activity site," an interpretation with which ERA concurs. Mabry also noted ground stones,cores,and scrapers on the site, while ERA observed a pulping plane, utilized flakes, and some possible ground stone fragments.

3.1.4 Isolate No. 1

The isolate identified during the survey was a single chert core. It will be submitted by ERA to the Anthropology Lab at California State University at Fullerton for permanenet curation.

3.2 POSSIBLE LOSSES OF CULTURAL RESOURCES

The two lithic scatter sites (LA/OMA Site Nos. 2 and 4, CA-Ora-762 and CA-Ora-761, respectively) do contain data on special use/activity sites, the scientific importance of which has not been studied previously in this part of California. Such sites, however, do contain useful scientific information (cf. Schiffer, Sullivan, and Klinger, 1978) and should therefore be protected from the current sand and gravel operation and future construction activity.

LA/OMA Site No. 3 is either an extension of CA-Ora-244 or associated with it as a satellite site. In ERA's opinion, the site has one of the most dense, if not the most dense, surface distribution of artifacts of any site in Orange County. Undoubtedly, the site is of great significance to the prehistory and early history of Orange County. The most recent report on CA-Ora-244 (cf. SRS, 1978) states that the site was visited by the Portolá Expedition of 1969 (cf. Smith, 1965) and that it is "one of the most important and significant archaeological/historical resources in the County of Orange . . . (and) that the site may well quality for nomination to the National Register of Historic Places."

The UCLA Archaeological Survey stated that LA/OMA Site No. 3 "seems to be worthy of inclusion on the National Register of Historic Places." It further recommended that ERA "record the site area for nomination to the Register and that (ERA) recommend the site area be preserved from all development" (cf. Rosen, 1979).

3.3 MITIGATION OF ADVERSE IMPACTS

Due to the nature of the data, LA/OMA Sites Nos. 2 and 4 (CA-Ora-762 and CA-Ora-761, respectively) ought to be protected. At a minimum, mitigation measures should consist of the following:

- A complete, systematic surface collection
- A statistically determined random sampling program consisting of subsurface exploratory units and/or auger holes to ascertain whether or not these sites have any depth.

Since the sites are currently in some danger from the sand and gravel operation, mitigation measure No. 1 probably should be implemented immediately. A proper research design should be developed to implement the sampling program, taking into account the scientific utility of small, sparse data sites (cf. Schiffer, Sullivan, and Klinger, 1978). The mitigation program also should include proper quantitative analysis and full disclosure of the results. The data obtained from the sites should be specifically and properly curated, possibly at California State University at Fullerton, if accepted.

LA/OMA Site No. 3 (CA-Ora-244 or extension thereof) appears to have highly significant prehistoric and historic cultural value. It is essential that it be preserved in its entirety for the scientific and humanistic appreciation of this and future generations. Since part of the site already has been destroyed by the sand and gravel operation, it is urgent that the following protective measures be taken immediately:

- The LA/OMA site development plan, including all roads, should avoid this portion of Round Canyon. A buffer also should be provided in order to protect the site during construction.
- All present authorities/participating parties (Irvine Company, the Sand & Gravel Operator, Orange County Sanitation District, LA/OMA Project, and any others that may be involved/affected) should be notified of the significance of the site and the danger imposed by current and proposed activities so that all human and vehicular traffic can be restricted.

- The site should be totally fenced, incorporating all new fencing into the existing one that separates the site from the sand and gravel operation.

- No signs or other notices that might provoke untoward interest should be posted at the site in order to protect it from lay artifact collectors, vandalism, etc.

- The present owner(s) should support ERA's nomination of the site to the National Register of Historic Places in order to facilitate its preservation.

- No further archaeological work (surface collection, excavation, etc.) should be undertaken at the site without the prior approval of the State Historic Preservation Office (SHPO), the State Regional Clearing House (UCLA), the Orange County Planning Department, and the Orange County Archaeological Cooperative Group. This approval should include the selection of the P.I. and the research design.

Since only a 10 percent survey was conducted at Round Canyon, a 100 percent surface survey should be conducted on the specific property ultimately selected for implementation of the OCSD sludge management plan. This survey would determine whether other sites are present and the appropriate mitigation measures to be recommended.

In order to insure the professional quality of the work, it is recommended that the P.I. who will be responsible for implementing the above mitigation measures be selected from the list of qualified professionals prepared by SOPA.

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APPENDIX B5

SYMBOLIC RELATIONSHIP BETWEEN HOUSES AND SELF-IDENTITY

Privacy is basic to the development and maintenance of a strong sense of personal identity, the search for which is a fundamental human characteristic. Privacy, both operationally and conceptually, involves not only a feeling of being alone but also a sense of possession of space, property, and time, each of which becomes an extension of the individual and serves as a measure of uniqueness and self-expression. Territoriality, which in humans is defined as achieving and exerting control over a particular space, is instrumental in attaining and maintaining this privacy. Territoriality becomes one way in which an individual can maximize freedom of choice in any given situation and thus the opportunity for self-expression and individuality. (Refs. 1-3.)

The concept of territoriality involves more than X number of people per given space. More germane is the functional organization and meaning of a particular space, together with an individual's past experiences and present expectations of such spaces. Together, these will determine the degree of privacy necessary for an individual to exercise freedom of choice and express individuality in any given situation. (Refs. 2,3.)

Strong societal counter-pressures for conformity and togetherness exist with the need for individuality, aggravating and/or increasing personal conflicts in contemporary society. As a result, the quantity and quality of socially acceptable personal possessions are emphasized at the expense of uniqueness. Although the need for identity still remains, it tends to become a function of "things" rather than personal self-knowledge. (Ref. 3.)

Expressions of self-identity, or the lack thereof, are most apparent in residential areas. Historically, man has attempted to described the inexplicable "who/what am I" in terms of physical forms or symbols that were at once close, visible, definable, and meaningful. The first and most conscious symbol for "self" was the body, since it appeared to be both its outward manifestation and its encloser. The second, although less conscious symbol, became the house, which similarly served as a tangible, public reflection of the "self" it contained. In contemporary society, owning a house that is somewhat different and expressive of originality is thus an important source of identity in an increasingly conformist world. On the other hand, having "too different" a house labels its inhabitant a nonconformist, which, for Americans, is a label to be avoided. (Refs. 4,5.)

In America, the house-as-symbol-of-self is a deeply ingrained by-product of the western frontier and the image of the "self-made man". As a result, the ideal house is an owner-occupied, detached, single-family structure surrounded by a yard. Apartments and subsidized dwellings, which do not fit into this description, are thus often viewed as a violation of territoriality and a threat to one's self-image as a separate, unique, independent individual. The vandalism inflicted on high-rise housing projects in particular is thought to be, at least in part, an aggressive reaction against this loss of self-identity. (Refs. 4,5.)

The symbolism between self and house, therefore, creates a dynamic, interdependent relationship in which "messages" move back and forth, reinforcing both negative and positive images. In short, there is a very real danger that the symbol, whether consciously chosen or not, may become a substitute for self-identity. (Refs. 4,5.)

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PROCESS FOR COMPARATIVE EVALUATION OF ALTERNATIVE SLUDGE MANAGEMENT PROJECTS

- PROCESS OVERVIEW
- SYSTEM OF COMPARISON
- EVALUATION CRITERIA
- QUALITATIVE EVALUATIONS

APPENDIX C1

PROCESS FOR COMPARATIVE EVALUATION OF ALTERNATIVE SLUDGE MANAGEMENT PROJECTS

The objectives of the comparative evaluation process were identification of essential differences among alternative sludge management projects and the identification of tradeoffs associated with implementation of the respective alternative projects. Basic steps of the process were (1) evaluations of alternative projects,(2) comparison of alternative projects and tradeoff identification, and (3) plan selection.

PROCESS OVERVIEW

Each of the alternative sludge management projects were analyzed by a team of LA/OMA Project staff and consultants. These technical evaluations addressed the considerations of (1) engineering practicability, (2) environmental acceptability, (3) marine biological resources, (4) implementation potential, and (5) quantitative characteristics. Input from the public participation program was evaluated and the results included in the consideration of implementation potential. Quantitative information such as cost and energy requirements was developed during this step of the process.

Results form the evaluation of the alternative projects provided the data for use in comparison of alternative projects. Advantages and disadvantages were identified for each of the aforementioned considerations for each of the alternative projects. A broad ranking of projects was developed within each considertion using the identified advantages/disadvantages. These rankings were used to compare alternative projects using all considerations and to identify potential tradeoffs associated with each of the alternatives. From this comparison, certain alternatives were found to be illsuited as the basis for the proposed sludge management program; some alternatives were identified as having better future prospects for the basis of the proposed program; and certain alternatives were identified as providing a good basis for the sludge management program. The proposed sludge management program was developed from this last group of alternatives.

During the evaluation and comparison of alternative projects, care was taken to give each of the considerations equal weight. Selection of the proposed management program, however, involved assignment of relative importance to the individual considerations by the LA/OMA Project Policy Board at the time of plan selection.

The Policy Board was provided the results of the project evaluations and tradeoff identification at a two-day workshop session. Information was presented for each consideration, including the ranking of projects within each consideration. Using results of discussions at the workshop sessions, Project Staff formulated recommendations regarding the goals and principles to guide preparation of the sludge management program and facilities plan and the conceptual nature of the proposed program for each operating agency.

After consideration of Project Staff recommendations, the LA/OMA Project Policy Board approved goals and principles and the conceptual nature of the management program for each operating agency. This action by the Policy Board concluded the comparative evaluation process. Subsequent efforts were directed towards preparation of facilities plans for each agency and the environmental impact statement/report required by State and Federal environmental legislation.

SYSTEM OF COMPARISON

By design, the system for comparison was capable of (1) giving adequate consideration to a combination of qualitative and quantitative information, (2) evaluation of components which do not have established standards, and (3) comparison of widely disparate components of the considerations of engineering practicability, environmental acceptability, marine biological resources, implementation potential, and quantitative characteristics. A system of measurement and procedural guidelines for project evaluations, comparison, and tradeoff identification were developed and used.

Project evaluations and comparisons were facilitated by separate identification of marine biological resources as a consideration apart form the remainder of the environmental concerns. Only the Baseline, Deep Ocean, and Barge Disposal projects provide ocean disposal of sludge while other alternatives provide for management of sludge on the land. Since the ocean is an element of these projects only, evaluation of potential effects under these projects provided the information necessary to compare ocean disposal of sludge with alternatives involving management on the land.

Each of the major considerations were divided into major factors of concern. Examples of factors within the consideration of environmental acceptability include public health, biotic resources and public facilities. Each major factor within each consideration was further divided into components. For example, the public health factor of the consideration of environmental acceptability was subdivided into the components of air pollutants, heavy metals, pathogens, and trace organics. Each of the considerations listed earlier were evlauated at the component level. Carrying the previous example further, potential public health effects associated with air pollutant emissions, and exposure to heavy metals, trace organics, and pathogens were assessed for each of the alternative sludge management projects.

For purposes of comparison, alternative sludge management projects were categorized within each of the qualitative considerations (environmental acceptability, engineering practicability, and implementation potential) according to four broadly defined groups. Group I included alternatives characterized by an overall positive combination of traits as defined by the evaluation criteria (see Table 1 following) or which did not possess a substantial number of negative traits as defined by evaluation criteria. Group IV included those projects which were characterized by an overall negative combination of traits as defined by the evaluation criteria or which possessed few positive traits as defined by the evaluation criteria. Groups II and III included projects with intermediate overall combinations of traits. Quantitative information was rank ordered and combined with the qualitative project grouping for overall comparison of alternative projects.

EVALUATION CRITERIA

Conclusions regarding the qualitative aspects of sludge management projects were generally reached through application of professional judgement and experience. The system of measurement selected for qualitative considerations needed to provide a measure of latitude to accommodate the mathematically imprecise nature of these conclusions. On the other hand, quantitative information is mathematically precise and was to be considered together with qualitative information.

Two kinds of systems were used in the comparative evaluation. For qualitative considerations, evaluation criteria were established independently of the magnitude or distribution of effects. For quantitative considerations a relative system of measurement (e.g., rank order) was utilized.

QUALITATIVE EVALUTIONS

Evaluation criteria were established for the considerations of engineering, en vironmental, implementation, marine biological resources.

In establishing the evaluation criteria care was taken (1) to utilize evaluation categories which have essentially the same meaning for all considerations and (2) to establish a neutral midpoint with a range of sequentially "better" and "worse" criteria. Thus a degree of uniformity was established between the disparate considerations thereby allowing comparison of the inherently different components.

Table 1 lists the evaluation criteria for the engineering, environmental and implementation considerations. The evaluation categories shown are broad continuums of significance ranging from "excellent" to "poor".

Environmental Acceptability

Evaluation criteria center around the neutral or "no change" midpoint. Benefits to the environment are generally distinguished between "good" and "excellent" by the degree of the significance of the change. On the other hand, detrimental effects are distinguished between "fair" and "poor" by the absence or presence of serious long-term implications. Two principal long-term implications are preclusion of future beneficial uses(s) and irreversible commitment of resources.

TABLE 1

EVALUATION CRITERIA FOR QUALITATIVE CONSIDERATION

CATEGORY	ENGINEERING PRACTICABILITY	ENVIRONMENTAL ACCEPTABILITY	IMPLEMENTATION POTENTIAL
Excellent	Long term use in municipal wastewater treatment with good repeatable success, easily adaptable, degree of sophistication associated with primary treatment.	Considerable improvement over existing conditions	High degree of acceptability; judged with a high degree of certainty to be compatible with applicable laws and related planning; minimal time for implementation (terminates all sludge discharge to the ocean by the end of 1981).
Good	Applied in municipal wastewater treatment with mostly successful results; moderately adpatable; degree of sophistication associated with advanced primary treatment. 1/	Some improvement over existing conditions	Moderate degree of acceptablility; legal or planning compatibility dependent upon policy interpretation (waivers and exemptions not included); moderate amount of time required for implementation (5 years or less).
Neutral	Limited use in LA/OMA area but accepted practice in other areas of U.S. with good repeatable success; adaptable with some difficulty; degree of sophistication associated with the conventional activated sludge process.	Insignificant improvement or detrimental change; concurrent improvement and detrimental change of approximately the same magnitude and significance.	Indeterminate acceptablility; any incompatibility believed resolvable through further study during predesign; intermediate amount of time required for implementation (5-10 years).
Fair	Limited utilization in municipal wastewater treatment with questionable success; questionable adpatability; degree of sophistication associated with advanced treatment processes.	Unavoidable 2/ adverse change in existing conditions but without serious long-term implications.	Low degree of acceptance; formal administrative action to establish regulations, grant a waiver or exception or to change regulations is necessary to assure legal or planning compatibility; substantial amount of time required for implementation of (10-15 years).
Poor	Not utilized in municipal wastewater treatment or limited application with many demonstrable unsuccessful results; minimal adaptability; degree of sophistication associated with highly mechanized industrial processes.	Unavoidable adverse change in existing conditions with serious long-term implications.	Strong opposition. Legislative or judicial action required to change law or interpretation thereof is necessary to assure legal or planning compatibility; excessive amount of time required for implementation (more than 15 years).

1/ Solids removal (about 80%) in excess of primary treatment but less than secondary treatment through polymer addition prior to primary settling.

2/ Adverse changes that will not be mitigated with implementation of a proposed action or with continuation of existing practices mitigated.

Engineering Practicability

Evaluation criteria for this consideration were based upon the conclusion that systems with long-term successful application in municipal wastewater treatment or which are easily adaptable to changing conditions; or which are relatively unsophisticated in nature have a high degree of expectation of cost effective performance as designed. Conversely, the criteria place in the lowest category, systems with no widespread application, or application with questionable results; or which are highly sophisticated in nature.

The neutral midpoint is based upon the fact that lack of application in the LA/OMA area should not significantly affect the expectation of long-term cost effective operation although short-term problems may result; that adaptability may be achievable with some difficulty (e.g., substantual funds or redesign involving state or federal grant assistance); and recognizes that the LA/OMA agencies will utilize the activated sludge process for secondary treatment.

Implementation Potential

While technical facts and conclusions may point to an alternative as the indicated or preferred solution, the implementation potential may be low or nonexistent. Thus a technically viable alternative may be of little use if it cannot be implemented. Consideration of implementation potential has been divided into the factors of regulatory compatibility, acceptability, and practicality.

- ### Regulatory Compatibility

  Planning and regulatory compatibility was evaluated with respect to requirements associated with water resources, air resources, land resources, and waste management. The evaluation criteria shown in Table 1 are based upon the conclusion that implementation potential is greatest if a project is in full compliance with established laws and regulations and has a good measure of consistency with related activities. This does not exclude the possibility for changing laws and regulations but as the criteria show, the need for such actions are believed to reduce implementation potential. Further. it was assuemd that formal administrative or legislative actions would increase impairment of implementation potential.

- ### Public Acceptance

  Criteria for evaluation of acceptability of the projects are defined in Table 2. Data for the evaluation are obtained through the LA/OMA Project Public Participation Program.

  Generally, public input is not tailor-made to fit predetermined evalaution criteria directly. Most often, input will advise what NOT to do and quite often, individuals will use opportunities for comment as a means to express views on related subjects not under consideration or control of the LA/OMA Project. Because of the nonuniform nature or input, a series of steps will be used to define input in terms of sludge management in general. These conclusions are then

TABLE 2

PUBLIC ACCEPTANCE EVALUATION CRITERIA

LEVEL OF ACCEPTANCE	CRITERIA
High	Major and most minor concerns can be resolved* or are nonexistent. Input is believed to be significantly representative. No further study or apparent contradictions indicated. (*Mitigation measures can be readily taken to satisfy the concerns)
Moderate	One or more major concerns remain to be resolved; however, most are resolved or are nonexistent.* Some significant minor concerns remain to be resolved. Input is believed to be moderately representative. Some minor needs for further study and some minor apparent contradictions exist. (*Mitigation measures can be taken, but with less ease or certainty than the "high" category.)
Indeterminate	May not be able to determine if major concerns are sufficiently resolved, or nonexistent. Some unresolved minor concerns which may be of significance. May not be able to determine if input is representative. Needs for additional study and apparent contradictions can be addressed during evaluation of conceptual plant.
Low	Several major concerns are unresolved. Several unresolved minor concerns exist. Input is believed to be moderately representative. One or more major needs for further study or apparent contradictions exist.
Strong Opposition	Most major concerns cannot be resolved and unresolved minor concerns are closely related to major concerns. Input believed to be significantly representative. Further major study needs are identified but not likely to resolve concerns in reasonable time. Major apparent contradictions do not exist.

applied to the alternative projects and the acceptability of each project determined. The basic steps for evaluation of public acceptance are:

- Review input for relevant comments.
- Identify major and minor concerns expressed.
- Identify items that require further study or analysis.
- Determine the significance of the comments.
- Consider the apparent motives behind the concerns expressed.
- Identify the magnitude and nature of support/opposition.
- Draw conclusions regarding the conditions of acceptance without regard to specific projects.
- Compare the conditions of acceptability with the alternative projects and derive conclusions regarding the acceptability of each of the individual projects.

Comments were considered relevant if they can be addressed by a sludge management decison. Major Concerns are comments shared by a majority of persons at a meeting or which is repeated several different times. On the other hand, Minor Concerns are comments expressed by few persons and may or may not be repeated several different times.

Significance of the representation was determined after consideration of the adequacy of notification of meetings, the numbers of persons in attendance at meetings, the amount of meaningful relevant comments offered, and the degree of indicated organization and potential for followup by interested persons.

Mitigation measures may be used to resolve major or minor concerns. Mitigation may already be incorporated in the alternative projects or may be accomplished by some action apart for the project facilities. The practicability of specific mitigation actions was considered when drawing conclusions.

Comments may point out the need for further study to adequately respond to the concern being experessed. These needs were identified on an ongoing basis so that they may be included in project studies. Comments which were beyond the scope of the LA/OMA Project to address or which have not been addressed in Project studies and which are believed to adversely affect acceptance of any project were considered in the evaluation.

Apparent contradictions may occur when knowledge gained from other sources is not reiterated as a significant concern. For example, if other agencies' public participation efforts had disclosed a low level of acceptance for trucking of solid waste into the area of the wastewater treatment plants, an apparent contradiction would exist if LA/OMA public input did not also disclose a similar level of acceptance for trucking solid waste into the wastewater treatment plants for codisposal with sludge. The apparent contradictions were identified and considered in the evaluation of public acceptability.

- Practicality

  Implementation practicality was examined in terms of institutional requirements and elapsed time. In general the evaluation criteria reflect the conclusion that creation of new institutional arrangements, including new agencies, diminishes implementation potential. Elapsed time is also a measure of implementation potential since ability to comply with regulatory requirements may diminish with time and the cost of alternatives can be dramatically affected.

  The year 1981 was selected for inclusion in the criteria based upon the Congressional requirement that sludge dumping in the ocean be terminated by the end of 1981. The 5-year time increment shown in the criteria is based upon experience of the Los Angeles County Sanitation Districts in design and construction of effluent filters at inland wastewater reclamation plants.

Marine Biological Evaluations

Evaluation criteria for this consideration were the same as for environmental acceptability. The evaluation categories of excellent and good were, however, combined into a single category labelled beneficial while the fair and poor categories were combined to form a single adverse category. For purposes of project ranking and comparison, this consideration was combined with the results from evaluation of environmental acceptability.

QUANTITATIVE EVALUATIONS

The major quantitative information developed during the evaluation of alternative projects included economics (capital and operating costs), energy consumption and projection, and air pollutant mass emission estimates. For purpose of comparison of alternatives, a system of rank ordering economics and energy, and air pollutant mass emissions was used. Energy factors were assumed to be represented by economic information since both costs and credits for energy consumption and production were included in the economic analysis. Additionally,. effects of future energy price increases were included in the analysis of the effects of inflation upon capital and operating costs.

Economics and Energy

In order to rank order the projects it was necessary to select economic factors that were to be used as the basis for ordering. Current annual costs reflect only present costs and represent a short-term economic view. An interim plus base present worth analysis represents a long-term economic viewpoint, since it includes effects of inflation, implementation delay, and differing service lifes over a 47-year period. In addition to these, inflation has been determined to be a particularly significant sensitivity which could be considered as part of an economic assessment.

Rather than select one economic factor as the basis for project ranking, various combinations of factors were considered. Weights applied to each economic factor are shown in Table 3. Under the "Balanced View" approach, an equal weight was applied to short term economics and the combination of long term economics plus the inflation sensitivity. The latter was presented by year 20 annual costs with 12 percent inflation for energy and chemicals and 8 percent for labor and maintenance. The interim plus base present worth also included an across the board 8 percent inflation rate. To avoid excessive double accounting of inflation, long term economics were given a higher weighting. Short term economics were split evenly between net current annual costs and the agency share of same.

Under the "Long Term Economic View" all weight was given to long term economics. This was felt to represent one extreme viewpoint. Another is represented by the "Operating Cost View" where all weight is placed on operating costs. In this case, the weight was split evenly between agency share of current amortization but it was largely insignificant compared to operating costs in year 20.

All projects were quantitatively ranked relative to the baseline project for each economic factor shown in Table 3. For purpose of this ranking, the baseline project was assigned a value of 1.00. Weights shown in Table 3 were applied to each economic factor and projects ranked according to their total score. As a result of the analysis, it was found that project rankings were only affected to a minor extent by the economic view which is selected. Projects at the bottom of the ranking remain at the bottom. Likewise projects ranked at the top, remain at the top regardless of the economic viewpoint. No projects change from low to high rankings by changing the economic viewpoint. Since project ranking was found not to be sensitive to the economic viewpoint, the balanced view was selected as most representative of a wide range of economic interests.

Air Emissions

Air emissions from the Projects presented some difficulties in ranking. Five major air pollutants were considered in the analysis, namely particulates, nitrous oxide compounds (NOx), sulfur oxide compounds (SOx), hydrocarbons (HC), and carbon monoxide (CO). Different projects emit different amounts of each pollutant making a direct comparison somewhat difficult. The projects could be ranked for each pollutant but the five resultant rankings would be difficult to interpret.

To overcome this difficulty and to provide a more straightforward approach, the projects were ranked according to the sum of particulate, Nox, SOx, and hydrocarbon emissions. The rationale for direct summation of these pollutants was derived from analysis of the State and Federal ambient air quality standards. Considering the longest exposure times available for each pollutant, the ambient standards are very similar for each of the five pollutants except CO. The latter is greater by a factor of about 100. Consideraing particulate, SOx, and NOx, the National Primary Standards are 75, 80, and 100 ug/m^3 on an annual average basis. The hydrocarbon standard is 160 ug/m^3 for a 3 hour

TABLE 3

WEIGHTING FOR ECONOMIC FACTORS CONSIDERED FOR PROJECT RANKING

	BALANCED VIEW	LONG-TERM ECONOMIC VIEW	OPERATING COST VIEW
SHORT TERM			
Net Current Annual Cost(1)	25	0	0
Agency Share(2)	25	0	50
LONG TERM			
Interim + Base Present Worth(3)	35	100	0
SENSITIVITY			
Year 20 Annual Cost With 12% Energy Inflation(4)	15	0	50
Total	100	100	100

(1) Sum of annual capital and O&M costs less annual value of credits from resource recovery elements.

(2) Total annual O&M cost plus local agency share of annual capital costs.

(3) Present worth of capital, O&M, and credits for a 47 year period which includes operation of an interim project followed by construction and operation of the base or long-term project.

(4) Annual cost projected for year 20 following construction. Inflation at 8 percent is assumed for all O&M components and credits except energy.

exposure but would probably reduce to the above range for longer duration exposure. While a gram of one pollutant is not equal to a gram of another the ambient air standards do suggest a measure of equivalence between particulate, SOx, NOx, and hydrocarbons with CO being considerably less significant. The National ambient air standards were based primarily on health related impacts of the pollutants and, therefore, the suggestd equivalence must be understood in terms of this impact. The pollutants might have vastly differing impacts in other areas, for example, visibility.

Rankings were developed for both direct emission and direct emissions less offsets for electrical power productions that would be avoided.

ALTERNATIVE APPROACHES TO EVALUATION OF CADMIUM HEALTH EFFECTS

ACCEPTABLE DAILY INTAKE ●

THE KJELLSTROM DOSE-RESPONSE MODEL ●

APPENDIX C2

ALTERNATIVE APPROACH TO EVALUATION OF CADMIUM HEALTH EFFECTS

Cadmium is a heavy metal present in most sewage sludges. There is no known use or benefit from cadmium in human biological processes. Long term exposure to cadmium can result in adverse human health effects including renal dysfunction. Because cadmium can be absorbed by plants, concern has arisen over the public health significance from consumption of crops grown on sludge amended soils. Cadmium can also be ingested into the body by the respiratory route and there is similar concern over cadmium emissions from thermal processing.

Several approaches have been used to develop criteria for acceptable intakes of cadmium. Two of these will be discussed here; the concept of an acceptable daily intake, and the dose-response model developed by Kjellstrom.

ACCEPTABLE DAILY INTAKE

Kidney tubular dysfunction is the major adverse health effect of cadmium. The critical organ is the kidney cortex. Various concentrations of cadmium in the kidney cortex, ranging from 150 to 300 ug/g, have been considered as critical levels for physiological damage to the kidney. A very sensitive indicator of kidney damage is increased urinary excretion of the protein B_2 - microglobulin. In general, a kidney cortex cadmium level of 200 ug/g is most widely accepted as the critical level. Although mild or moderate increases in excretion of B_2 - microglobulin, per se, are not life threatening, the condition is often irreversible. Continued excessive exposure can lead to other renal function abnormalities, such as glycosuria, amino-aciduria and phosphaturia.

Various models have been established to calculate the daily level of exposure which will result in a cadmium concentration of 200 ug/g in the kidney cortex. U.S. EPA scientists reviewed these models (Ref. 1) and determined ingestion of 440 microgram of cadmium per day over a 50-year period as a reasonable estimate of the amount of cadmium necessary for 50 percent of the population to develop proteinuria. However, there are many individuals who may develop proteinuria at lower exposure levels.

A metabolic model by Friberg indicates that ingestion of about 200 ug/day over a 50-year period is the level at which most sensitive individuals accumulate 200 ug/g cadmium in the kidney cortex (Ref. 1).

A more recent dose-response model by Kjellstom and Nordberg (Ref. 2) suggests that there may be health effects in the population at even lower levels of cadmium exposure. For a 70 Kg. body weight and with a dietary intake of 108 to 148 ug/day, the model predicts an adverse response in 5 to 10% in the population after 50 years of exposure.

In 1972, the World Health Organization (WHO) used the Friberg Model and applied a margin of safety to allow for non-dietary sources and for sensitive individuals. A maximum dietary intake level of 71 ug/day for a 70 Kg. standard man was recommended. Therefore, the Acceptable Daily intake level was established at 71 ug/day (Ref. 3.)

However, based on the dose-response model of Kjellstrom and Nordberg, there is no threshold for cadmium induced health effect. Any level of exposure would have a corresponding response. Response rates of 1% and 2.5% renal tubular are predicted corresponding to dietary intakes of 60 and 80 ug/day, respectively, for a period of 50 years.

On the other hand, a group of U.S. EPA sceintists (Ref. 4) recommended that the EPA consider a policy of limiting total daily exposure for all sources to no more than 150 ug calculated in terms of ingestion equivalents. Such level would correspond to that of an individual ingesting 75 ug/day in food (near the upper level of current intake estimates) and who also smokes three packs of cigarettes a day, taking in another 75 ug/day equivalent of cadmium. Such 150 ug/day level would allow only a 50 ug/day safety margin below 200 ug/day critical level. This level (200 ug/day) is the current best estimate of the critical ingestion level which over a 50 year exposure period, would result in renal tubular dysfunction in sensitive members of the U.S. population. This U.S. EPA study was conducted to assist in the development of the Section 405 regulations as required by the Clean Water Act.

In the final promulgated regulations, EPA decided that a 70 ug/day level should be used, based on the Fribert Model. The ingestion level of 70 ug/day incorporates a larger safety margin than the original 150 ug/day recommendation. It was felt that more data exists to validate the Friberg approach than the Kjellstrom dose-response model at present. The Kjellstrom approach was described in Ref. 4 as an experimental attempt to improve the process of quantitative risk assessment for cadmium. However, it was considered premature to base regulatory decisions on its implications, pending further validation.

There is no general consensus on the current dietary intake levels of cadmium in the United States, but there is wide agreement that the daily intake levels vary significantly according to individual dietary habits. Based on annual market basket surveys conducted by the Food and Drug Administration (FDA), the median ingestion level is about 39 ug/day for male teenagers (Ref. 1). If the intake is adjusted by the recommended caloric intakes from birth to age 50 as determined by the National Academy of Sciences, the median intake would be 33 and 26 ug/day for male and female, respectively (Ref. 5).

Another approach to estimating cadmium intake levels is analysis of fecal excretion. The fecal excretion studies are based on the experimental finding that only about 6% of ingested cadmium is retained in the body, while the rest is excreted. Three recent fecal excretion studies give the mean dietary cadmium intake estimate at about 20 ug/day for American teenage males. These studies also showed significant individual variation with 1% of the sample exceeding 50 ug/day intake.

There are population groups for whom an increase of cadmium level in the diet may be more significant than for the average population. This would include smokers, vegetarians and people with nutritional deficiencies in calcium, zinc, protein and vitamin D. In order to afford more protection of sensitive individuals, the U.S. EPA (Ref.) used the FDA median intake of 39 ug/day along with an acceptable daily intake (ADI) level of 70 ug/day. A maximum allowable incremental increase of 30 ug/day in the diet was thereby identified for regulatory purposes.

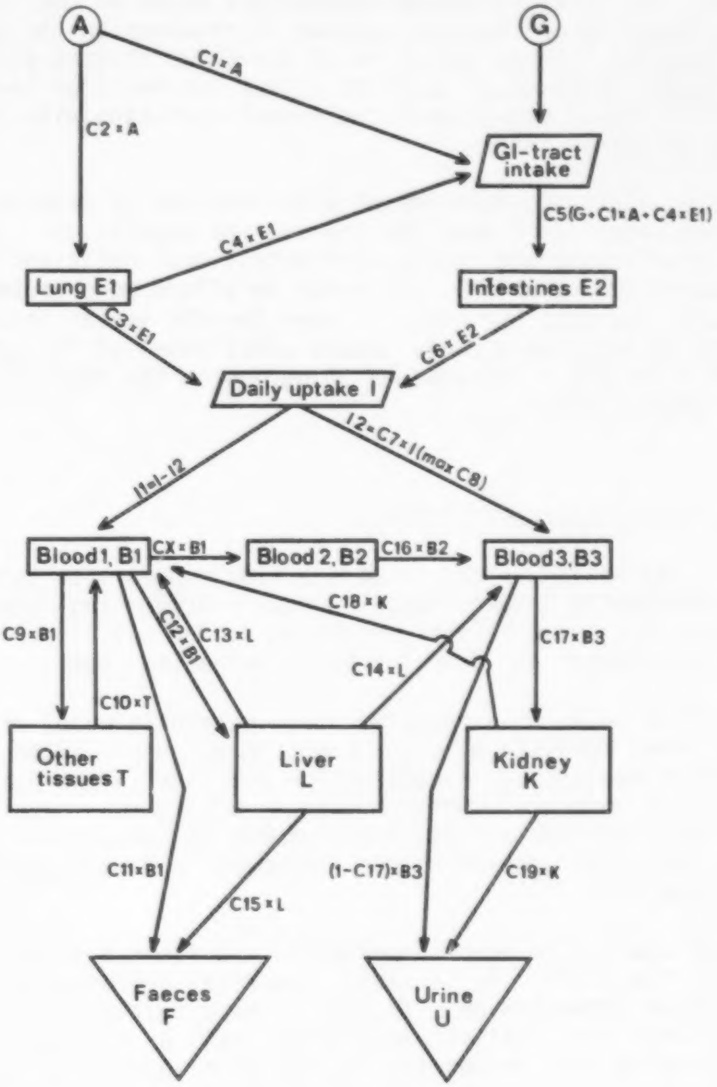
THE KJELLSTROM DOSE-RESPONSE MODEL

To examine the health effect resulting from exposure to cadmium, a cause and effect relationship between observed health effect and cadmium exposure is needed. Kjellstrom and Nordberg reported such a relationship based on epidemiological studies and computer based metabolic models.

The Kjellstrom model is a computer based metabolic model of moderate complexity. The model consists of eight compartments representing different organs and transport media (e.g. blood) of the body, an intake pool, an uptake pool and two excretion pools. Data on intake, absorption, transport, distribution, accumulation and excretion of cadmium in animals and man was used to formulate the human cadmium metabolism model. A flow diagram of the model is shown in Figure 1.

The flow of cadmium between compartments was assumed to follow first order exponential functions. An iterative numerical procedure was used to calculate cadmium accumulation with age in the compartments. The model and its 21 coefficients were initialized with the help of observed tissue concentrations in smoking and non-smoking Swedes, with and without occupational exposure to cadmium. Further details of the Model can be found in Reference 3.

Calculated dose-response relationships from the model correlate reasonably well with observations of Japanese groups with high cadmium exposure via food and workers with high exposure via air. Even though the metabolic model is approximate, it can tie together observations of cadmium in kidney cortex, liver, blood, urine and other tissues. Relatively good agreement between calculated kidney cortex cadmium concentrations and available empirical data was found both at low and high levels of exposure. Therefore, the model should be useful for approximate predictions of cadmium concentrations in the critical organ (kidney cortex) corresponding to different cadmium intake levels.



SOURCE=
Kjellstrom, T. and Nordberg, G.F., "A Kinetic Model of Cadmium Metabolism in the Human Being," J. Environ. Research 1977.

METABOLIC MODEL FOR CADMIUM

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

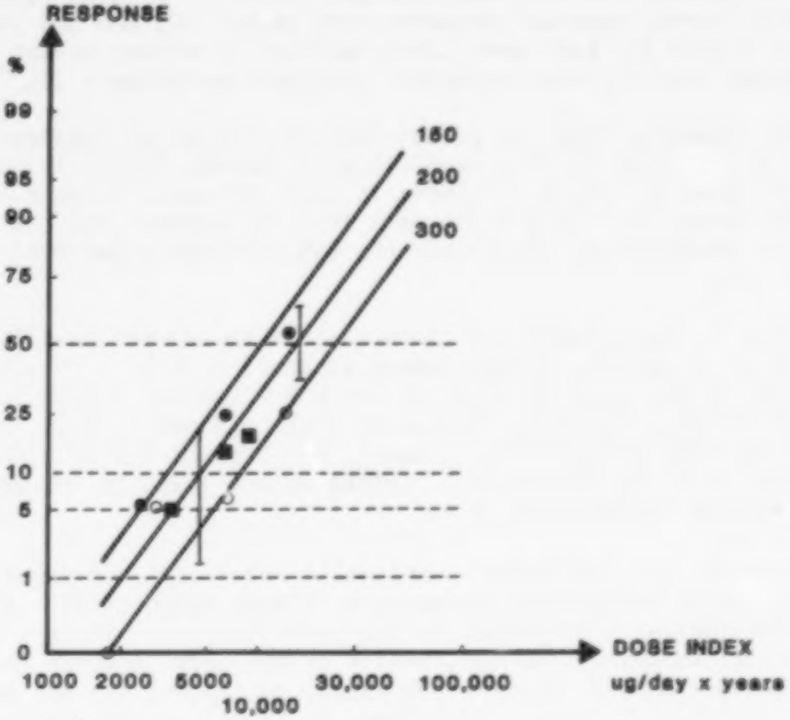
FIG. 1

Using the metabolic model, a dose-response relationship can be developed relating cadmium intake to subsequent concentrations in the kidney. The calculated response from a 50-year dietary intake of exposed Japanese groups with renal cortex cadmium concentrations above 150, 200 and 300 ug/g are given in Figure 2. Log-normal distributions of kidney cortex cadmium concentrations were assumed (geometric standard deviation = 2).

Observed responses from two epidmiological studies of Japanese farming populations exposed to long term elevated cadmium intake in their food (rice) are also shown in Figure 2. There is good agreement between calculated dose response curves and the grouped data from the epidemiological studies. All empirical observations lie within the 95% confidence intervals of the curve for 200 ug/g.

From Table 1, the present U.S. intake at 33 ug/day was calculated to induce a health response from kidney damage at about 0.1% or 1 in 1000. However, continuous intake over 50 years at the W.H.O maximum intake level of 71 ug/day could conceivably increase the health risk to about 1.6% or 16 in 1000. Therefore, according to Kjellstrom's model, the health risk of kidney damage would be increased if the present U.S. intake were allowed to increase towards the W.H.O. maximum recommended level.

In conclusion, the Kjellstrom's metabolic model is a non-threshold model, adjusted to the background incidence of kidney dysfunction. Any increase in cadmium intake is predicted by the model to result in some increase in health risk. However, the sensitivity of the model towards the lower end of the intake scale (i.e. below a 2000-3000 dose index) has not been substantiated with epidemiological data. Therefore, it is not certain whether an increased intake of a few ug/day would actually result in an observable higher health risk.



OBSERVED RESPONSE

- ● TOYAMA GROUP (50-59 YRS) .35 SUBJECTS
- ○ TOYAMA GROUP (40-44 YRS) .47 SUBJECTS
- ■ AKITA GROUP, 89 SUBJECTS

CALCULATED RESPONSE (BASED ON METABOLIC MODEL)

Lines for exposed Japanese (53 Kg. body wt. with renal cortex cadmium concentrations above 150, 200 and 300 ug/g. For Europeans (70 Kg. body wt., the dose index should be adjusted by a factor of 0.75, before the response is to be determined from the above chart.

DOSE INDEX = INTAKE VIA FOOD (ug/day) x EXPOSURE DURATION (YEARS)
RESPONSE = CADMIUM INDUCED INCREASE (>97.5% OF REFERENCE) OF URINARY B_2 - Micro globulin excretion, background adjusted.

BARS = STANDARD ERROR ESTIMATE FOR n = 12

CADMIUM HEALTH EFFECT
DOSE-RESPONSE MODEL

REGIONAL SLUDGE MANAGEMENT PROGRAM
LOS ANGELES/ORANGE COUNTY METROPOLITAN AREA

FIG. 2

TABLE 1

CALCULATED RESPONSE RATES OF KIDNEY DAMAGE FROM VARIOUS INTAKE LEVELS IN FOOD AT AGE 50

(Based on the Kjellstrom model)

INTAKE FROM FOOD	RESPONSE RATE OF KIDNEY TUBULAR DAMAGE
ug/day	% Exposed Population
32	0.1
60	1
80	2.5
108	5
148	10
440	50

Assumptions

European body wt. 70 Kg
Gastro-intestinal absorption 4.8%
Non-smoker

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C2-8

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APPENDIX C3

SOLID WASTE DISPOSAL ASSUMPTIONS ASSESSMENT OF ALTERNATIVES

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1) If R = the loading rate for refuse (cubic yards per year)
S = the loading rate for sludge (cubic yards per year)
C = landfill capacity
L_1 = landfill life, refuse only
L_2 = landfill life, refuse and sludge

then

$$RL_1 = C = (R+S)L_2$$

$$\frac{L_2}{L_1} = \frac{R}{R+S} =$$ The factor by which the useful capacity of the landfill for refuse would be multiplied to determine the reduced capacity for refuse with sludge added.

2) The following landfill loading rates (R) were assumed for refuse:

Lopez Canyon	900 tons/day	=	0.50×10^6 cu.yd./year
Puente Hills	5,000 tons/day	=	2.74×10^6 cu.yd./year
Prima Deshecha			1.67×10^6 cu.yd./year
Milliken	422 tons/day	=	0.23×10^6 cu.yd./year

The figures used for Lopez Canyon, Puente Hills, and Milliken were the same as those assumed for leachate absorption capacity calculations (Calculation of Projected Landfill Absorption Capacities, February 26, 1979, LA/OMA). The figure for Prima Deshecha is from Compilation and Analysis of Residual Wastes Data, County of Orange, SCAG No. 208-9c, November, 1977. (Average of 1980 and 2000 figures).

3) The following figures were used for sludge and refuse density (density in landfill after compaction):

Dewatered Sludge Cake	2.00 cu.yd. per dry ton
Compost	1.75 cu.yd. per dry ton
Ash or Char	0.60 cu.yd. per dry ton
RDF Inerts	2.00 cu.yd. per ton
Animal Waste Inerts	0.74 cu.yd. per ton

APPENDIX C4

TRANSPORTATION SYSTEMS ASSUMPTIONS ASSESSMENT OF PROPOSED SLUDGE MANAGEMENT PROGRAM

A maximum number of daily movements was established, based on worst-case conditions of two days supply of material being moved in the succeeding week. This resulted in an increase of approximately 40 percent over the existing average daily trips. The average headway of vehicles from the plant to the landfills was originally based on an 8-hour day. Because of anticipated delays and normal schedule fluctuations, however, the headways were calculated for a peak condition based on a 7-hour/day. Therefore, these figures are slightly more intensive than those contained in the original estimates.

The following assumptions were made concerning the amount of material to be loaded into the vehicles, the types of vehicles, and the characteristics of the material itself:

- The vehicles to be used would be conventional double-bottom, open tractor trailers used for moving large volumes of material such as earth or other excavation.

- The normal loading on vehicles would be 20 tons per vehicle, although in some instances loads as high as 25.5 tons were used in the calculation of number of vehicles required. A check of the maximum loads allowed on California highways indicated that a maximum load per axle of 20,000 pounds, or ten tons, is standard. It would appear that there would be no problem with overloading.*

- Two types of materials would be carried: one wet cake and the other ash and char. The wet cake material would be sufficiently dense and dried that it would not represent a spillhazard when carried in open trucks. It was understood that if spillage became a problem that the trucks would be covered. Similarly, it was understood that the char and ash would be sufficiently dense that they would not create dust during transport. If this were to become a problem, it also was understood that the trucks would be suitably covered. It should be noted that if covering of vehicles is required, that the operation would be slowed down slightly in instances where large volumes of material were being moved and headways were in the vicinity of 3 to 4 minutes.

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*20,000 lb. axle loading is from Section 35-5.50 of the California Vehicle Code.

It was assumed that the impact of vehicles carrying material from the treat-plant to the landfill site would not result in any measurable impact of traffic while on the freeway system. It was anticipated, however, that these vehicles could encounter peak-hour traffic conditions, which could result in longer running time during these periods. However, the impact would be on the landfill operation rather than on the movement of traffic in the greater Los Angeles area.

SOLID WASTE DISPOSAL ASSUMPTIONS FOR ASSESSMENT OF PROPOSED SLUDGE MANAGEMENT PROGRAM

REFERENCES ●

APPENDIX C5

SOLID WASTE DISPOSAL ASSESSMENT OF PROPOSED SLUDGE MANAGEMENT PROGRAM

The following landfill loading rates (R), based on 1978 totals, were assumed for refuse after compaction:

• Bee Canyon (Ref. 1)	1,000,000 tons/year	=	1.5×10^6 yd^3/year
• BKK (Ref. 2)*	884,799 tons/year	=	1.3×10^6 yd^3/year
• Calabasas (Ref. 3)*	47,530 tons/month	=	0.86×10^6 yd^3/year
• Lopez Canyon (Ref. 4)	921 tons/day	=	0.50×10^6 yd^3/year
• Puente Hills (Ref. 4)	5,000 tons/day	=	2.74×10^6 yd^3/year

The figures used for Lopez Canyon and Puente Hills were the same as those assumed for leachate absorption capacity calculations (Ref. 4).

The estimated remaining life (from Jan. 1978) for the landfills is as follows:

	Remaining Life
• Bee Canyon (Ref. 1)	60 Years**
• BKK (Ref. 5)	76 Years
• Calabasas (Ref. 5)	53 Years
• Lopez Canyon (Ref. 5)	30-33 Years
• Puente Hills (Ref. 5)	30 Years

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*Only solid refuse received at the landfill was included in the loading in order to provide a worst case analysis of program impacts.

**From date of opening, 1983.

Percent solids for sludge residuals were assumed to be:

Char/Ash	1.00
Wet cake	.18-.23
Compost	.50
Digester residue)) FGD scrubber sludge)	.50

The following figures were used for sludge and refuse density in the landfill after compaction (Ref. 7):

Refuse	1.50 yd^3 per dry ton
Dewatered sludge cake	2.00 yd^3 per dry ton
Compost	1.75 yd^3 per dry ton
Char/ash	0.60 yd^3 per dry ton
RDF inerts	2.00 yd^3 per dry ton
Animal waste inerts	0.74 yd^3 per dry ton
Digester residue	1.10 yd^3 per wet ton
FGD scrubber sludge	1.10 yd^3 per wet ton
CG product	1.10 yd^3 per dry ton

Absorption capacity of refuse received at Puente Hills was assumed to be 90L/1,000 Kg. of as-received refuse.

REFERENCES

1. Personal communication. Poer, Don. Orange County Environmental Management Agency. October 5, 1979.

2. Personal communication. Johnson, Joe. October 10, 1979. Chancellor and Ogden, Inc. Wilmington.

3. Personal communication. Dowdell, Chuck. October 5, 1979. Sanitation Districts of Los Angeles County.

4. LA/OMA Project. 1979. "Calculation of Projected Landfill Absorption Capacity."

5. Los Angeles County Sanitation Districts. 1979. Nonsewerable Waste Study for the Los Angeles/Orange County Metropolitan Area.

6. Southern California Association of Governments. 1979. 208 Plan Elements Report. Vol. 7, Appendix A.

7. Memo from LA/OMA Project. June 1, 1979.

8. County Sanitation Districts of Los Angeles County. 1978. "LA/OMA Project Landfill Demonstration Project" Draft Report.

APPENDIX C6

WET WEATHER OPERATIONS LOS ANGELES COUNTY SANITATION DISTRICTS

Table C-1 indicates the periods of heavy rainfall in the Los Angeles region since 1900. Rainfall is shown for all months that exceeded six inches, and for all sequences of months during which at least four inches of rain occurred on consecutive months. Calculations were done for a number of these rainy periods to determine how much the storage capacity would have been exceeded had the proposed Phase II Facilities been in operation at JWPCP at the time.

Assumptions used were:

1)	Input	500 DTPD
	Dewatering	- 20
		480
	CG/DWTP	-360
		120

• On rainy days, 75 tons to landfill	120-75=45 tons to storage
• On dry days, 150 tons to landfill	150-120=30 tons removed from storage
• On Sundays, landfill closed	120 tons to storage regardless of weather

2) No composting would occur during the periods in question.

3) All three thermal processors would operate continuously.

4) There would be no need to store sludge during the periods in question because of maintenance shutdowns, repairs, etc.

The following three case studies, which were selected from the periods of heaviest rainfall, illustrate the range in sludge volumes that would have required ocean disposal. The average volume for the entire period would have been about 450 tons if the tanks had been empty at the beginning of the rainy period. (A letter T in the rainfall column indicates trace precipitation.)

Figures in the right-hand column in the case studies indicate how much the storage capacity would have been exceeded had the storage tanks been empty at the end of the day preceding the start of the rainy period. If the day preceding the start of the rainy period was a Sunday, it was assumed the tanks would contain 120 dry tons of stored sludge, since this amount would be stored every Sunday, and there would have been no opportunity to remove it from storage.

Figures in the last column indicate how much the storage capacity would have been exceeded if it were assumed the tanks contained 720 dry tons at the end of the day preceding the rainy period because of maintenance shutdowns, repairs, etc. (Subsequently, however, assumption No. 4 above was applicable.)

TABLE C-1

HISTORICAL RAINFALL DATA[1]
LOS ANGELES/ORANGE METROPOLITAN AREA

	MONTH					
YEAR	NOV	DEC	JAN	FEB	MAR	APR
1978		4.70	7.70	8.91	8.02	
1973			4.39	7.89		
1970	5.05	4.92				
1969			14.94	8.03		
1966	4.07	5.26	5.93			
1965	9.68	5.73				
1962			2.56	11.57		
1958				6.46	5.30	
1956			8.39			
1952		5.80	10.03	0.63	6.14	
1946	6.04					
1944		6.23	0.97	8.65		
1943			7.98	3.07	4.55	
1941		5.50	2.21	12.42	8.14	
1940			4.33	5.43		
1939		7.26	2.96			
1938			9.81	7.94		
1937		6.63	1.99	7.87	4.04	
1936				7.25		
1934		8.48				
1933			8.46			
1931			5.93			
1927				9.03		
1926						7.53
1922		7.90	4.64	3.47		
1918				6.14	6.21	
1916			13.30			
1914			10.35	7.04		
1913				9.16		
1912					6.99	
1911			6.70	2.91	5.15	
1910		7.00				
1909			7.27	5.20		
1907		5.12	7.02			
1906					7.35	
1905				6.06	6.00	
1903					6.93	
1900	6.53					

SOURCE: National Oceanic and Atmospheric Administration (NOAA)

1. Periods exceeding six inches and all consecutive months exceeding four inches.

CASE STUDY NO. 1: LOWEST VOLUME TO OCEAN

MO/YR	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
FEB 1962	6				720	
	7		.43	45	765	
	8		2.43	45	810	
	9		.95	45	855	
	10		2.55	45	900	
	11	Sun	1.24	120	1020	
	12		.43	45	1065	
	13			- 30	1035	
	14		.03	45	1080	
	15		1.35	45	1125	
	16		.20	45	1170	
	17			- 30	1140	
	18	Sun		120	1260	
	19		1.72	45	1305	
	20		.21	45	1350	
	21			- 30	1320	
	22			- 30	1290	
	23			- 30	1260	
	24		.03	45	1305	
	25	Sun		120	1425	
	26		T	- 30	1395	
	27			- 30	1365	
	28			- 30	1335	
MAR 1962	1			- 30	1305	
	2			- 30	1275	
	3			- 30	1245	
	4	Sun		120	1365	
	5		T	- 30	1335	
	6		.47	45	1380	
	7			- 30	1350	
	8			- 30	1320	
	9		T	- 30	1290	
	10			- 30	1260	
	11	Sun		120	1380	
	12			- 30	1350	
	13			- 30	1320	
	14			- 30	1290	
	15			- 30	1260	
	16		T	- 30	1230	
	17			- 30	1200	
	18	Sun	.13	120	1320	
	19		.02	45	1365	
	20		.05	45	1410	
	21			- 30	1380	
	22		.13	45	1425	
	23			- 30	1395	
	24			- 30	1365	
	25	Sun		120	1440	45
						45

- Total volume of sludge to ocean = 45

- Total amount of rainfall:

Feb 1962 11.57 inches
Mar 1962 1.10

CASE STUDY NO. 2: MID-RANGE VOLUME TO OCEAN

MO/YR.	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
DEC 1968	15	Sun			720	
	16		.22	45	765	
	17			- 30	735	
	18			- 30	705	
	19		.03	45	750	
	20		1.24	- 30	720	
	21			- 30	690	
	22	Sun		120	810	
	23			- 30	780	
	24			- 30	750	
	25		.35	45	795	
	26		.56	45	840	
	27			- 30	810	
	28			- 30	780	
	29	Sun	.02	120	900	
	30			- 30	870	
	31			- 30	840	
JAN 1968	1			- 30	810	
	2			- 30	780	
	3			- 30	750	
	4			- 30	720	
	5	Sun		120	840	
	6			- 30	810	
	7			- 30	780	
	8			- 30	750	
	9			- 30	720	
	10			- 30	690	
	11			- 30	660	
	12	Sun		120	780	
	13		1.12	45	825	
	14		.36	45	870	
	15			- 30	840	
	16			- 30	810	
	17			- 30	780	
	18		.76	45	825	
	19	Sun	1.28	120	995	
	20		3.30	45	990	
	21		1.24	45	1035	
	22		.07	45	1080	

Case Study No. 2: Mid Range (cont)

MO/YR	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
	23		.25	45	1125	
	24		2.04	45	1170	
	25		3.43	45	1215	
	26	Sun	.78	120	1335	
	27			- 30	1305	
	28		.31	45	1350	
	29			- 30	1320	
	30			- 30	1290	
	31			- 30	1260	
FEB 1969	1			- 30	1230	
	2	Sun		120	1350	
	3			- 30	1320	
	4			- 30	1290	
	5		.26	45	1335	
	6		1.05	45	1380	
	7			- 30	1350	
	8			- 30	1320	
	9	Sun		120	1440	
	10			- 30	1410	
	11			- 30	1380	
	12		.02	45	1425	
	13			- 30	1395	
	14			- 30	1365	
	15		1.04	45	1410	
	16	Sun		120	1440	90
	17			- 30	1410	
	18		.39	45	1440	15
	19		.27	45	1440	45
	20		T	- 30	1410	
	21		.48	45	1440	15
	22		.05	45	1440	45
	23	Sun	2.11	120	1440	120
	24		.43	45	1440	45
	25		1.24	45	1440	45
	26		.01	45	1440	45
	27			- 30	1410	
	28		.68	45	1440	15
MAR 1969	1			- 30	1410	
	2	Sun		120	1440	90
	3			- 30	1410	
	4			- 30	1380	
	5			- 30	1350	
	6			- 30	1320	
	7			- 30	1290	
	8			- 30	1260	
	9	Sun		120	1380	
	10		.24	45	1425	
	11			- 30	1395	

Case Study No. 2: Mid Range (cont)

DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
12			- 30	1365	
13		.01	45	1410	
14			- 30	1380	
15			- 30	1350	
16	Sun		120	1440	30
					600

- Total volume of sludge to ocean = 600 tons
- If it were assumed that the total amount in storage at the end of the day on Sunday, December 15, were 120 tons, the storage capacity would not be exceeded during the period of the calculations, given the assumptions stated in Case Study No. 1.
- Total amount of rainfall:

Dec 1968	1.28 inches
Jan 1969	14.94
Feb 1969	8.03
Mar 1969	1.49

CASE STUDY NO. 3: HIGHEST VOLUME TO OCEAN

MO/YR	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
NOV 1906	21				720	
	22		.54	45	765	
	23		.01	45	810	
	24			- 30	780	
	25	Sun		120	900	
	26		.10	45	945	
	27		.02	45	990	
	28			- 30	960	
	29		.17	45	1005	
	30			- 30	975	
DEC 1906	1		T	- 30	915	
	2	Sun	.13	120	1065	
	3		.29	45	1110	
	4		T	- 30	1080	
	5			- 30	1050	
	6			- 30	1020	
	7			- 30	990	
	8		T	- 30	960	

Case Study No. 3: Upper Range (cont)

MO/YR	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
	9	Sun	.50	120	1080	
	10		T	- 30	1050	
	11		1.48	45	1095	
	12		.17	45	1140	
	13		T	- 30	1110	
	14			- 30	1080	
	15			- 30	1050	
	16	Sun		120	1170	
	17			- 30	1140	
	18			- 30	1110	
	19			- 30	1080	
	20			- 30	1050	
	21			- 30	1020	
	22		T	- 30	990	
	23	Sun	T	120	1110	
	24			- 30	1080	
	25		.01	45	1125	
	26		.57	45	1170	
	27		.57	45	1215	
	28		.91	45	1260	
	29			- 30	1230	
	30	Sun		120	1350	
	31		.47	45	1375	
JAN 1907	1			- 30	1365	
	2			- 30	1335	
	3			- 30	1305	
	4			- 30	1275	
	5		.84	45	1320	
	6	Sun	.34	120	1440	
	7		1.32	45	1440	45
	8		.53	45	1440	45
	9		1.32	45	1440	45
	10		.07	45	1440	45
	11			- 30	1410	
	12		.04	45	1440	15
	13	Sun	.16	120	1440	120
	14		.21	45	1440	45
	15		.25	45	1440	45
	16		.01	45	1440	45
	17		1.19	45	1440	45
	18		.13	- 30	1410	
	19		.02	- 30	1380	
	20	Sun	.05	120	1440	60
	21			- 30	1410	
	22		.13	- 30	1380	
	23			- 30	1350	
	24			- 30	1320	
	25		.01	45	1365	

Case Study No. 3: Upper Range (cont)

MO/YR	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
	26			- 30	1335	
	27	Sun		120	1440	15
	28			- 30	1410	
	29		.63	45	1440	15
	30		.07	45	1440	45
	31		.01	45	1440	45
FEB 1907	1			- 30	1410	
	2			- 30	1380	
	3	Sun		120	1440	60
	4			- 30	1410	
	5			- 30	1380	
	6			- 30	1350	
	7			- 30	1320	
	8			- 30	1290	
	9			- 30	1260	
	10	Sun		120	1380	
	11			- 30	1350	
	12			- 30	1320	
	13			- 30	1290	
	14			- 30	1260	
	15		.01	45	1305	
	16		.42	45	1350	
	17	Sun	.02	120	1440	30
	18			- 30	1410	
	19			- 30	1380	
	20			- 30	1350	
	21		.86	45	1395	
	22		.52	45	1440	
	23			- 30	1410	
	24	Sun		120	1440	90
	25			- 30	1410	
	26		T	- 30	1380	
	27			- 30	1350	
	28			- 30	1320	
MAR 1907	1			- 30	1290	
	2			- 30	1260	
	3	Sun	.05	120	1380	
	4		1.25	45	1425	
	5		.97	45	1440	30
	6		.03	45	1440	45
	7			- 30	1410	
	8		.07	45	1440	15
	9			- 30	1410	
	10	Sun	.02	120	1440	90
	11		T	- 30	1410	
	12			- 30	1380	

Case Study No. 3: Upper Range (cont)

MO/YR	DATE	DAY	RAINFALL	ADDED TO STORAGE	DRY TONS IN STORAGE AT END OF DAY	TO OCEAN
	13			- 30	1350	
	14			- 30	1320	
	15			- 30	1290	
	16			- 30	1260	
	17	Sun		120	1380	
	18			- 30	1350	
	19		.15	45	1395	
	20		.34	45	1440	
	21			- 30	1410	
	22		.46	45	1440	15
	23			- 30	1410	
	24	Sun	.51	120	1440	90
	25		.27	45	1440	45
	26		T	- 30	1410	
	27		T	- 30	1380	
	28			- 30	1350	
	29			- 30	1320	
	30			- 30	1290	
	31	Sun		120	1410	
APR 1907	1		T	- 30	1380	
	2		.10	45	1425	
	3			- 30	1395	
	4			- 30	1365	
	5			- 30	1335	
	6			- 30	1305	
	7	Sun		120	1425	
						1185

- Total volume of sludge to ocean = 1185
- Total amount in ocean if tanks assumed empty on November 21, 1906 = 1185-720=465
- Total amounts of rainfall

Nov 1906	0.85 inches
Dec 1906	5.12
Jan 1907	7.02
Feb 1907	1.83
Mar 1907	4.12
Apr 1907	0.16

APPENDIX C7

ENERGY SYSTEMS EVALUATION PROPOSED SLUDGE MANAGEMENT PROGRAM

Impacts resulting from implementation of the Proposed Sludge Management Program were assesed in terms of their relationship to the provision of energy by the quasi-public electrical utilities to the operating agencies, and to their service area, as a whole. Potential impacts on the provision of natural gas by the Southern California Gas Company were not evaluated because the proposed project would demand an insignificant amount of that fuel under worst-case conditions, and normal project conditions would not require any natural gas. The consumption of diesel fuel and other petroleum products was included in this assessment, although the level of consumption was not considered regionally significant, because of the high level of interest in petroleum supplies. For the reasons outlined above, the energy impact analysis concentrated on the ability of the Southern California Edison Company and Department of Water and Power, City of Los Angeles to provide electrical power.

Impacts of the proposed Sludge Management Program on energy resources were determined by comparing the effect of each agency's plan on energy production and consumption levels, and comparing the net production of energy to total electrical energy demand of the utility servicing each agency (e.g. Los Angeles Department of Water and Power and Southern California Edison Co.). Since each plan would result in a net production of energy, net production was compared in the aforementioned manner to determine its potential effect on relieving the pressure on electrical demand, and to determine the amount of energy self-sufficiency of each operating agency. Petroleum product consumption was also analyzed, although consumption was considered insignificant in terms of regional demand.

For the CLA and LACSD systems, electricity production from the direct fired thermal processor and the combined cycle power generator would be higher than total consumption of electricity from all system processes. Though gas from anaerobic digesters would be used to power processes that would have required electricity for operation at OCSD, it was not converted into electricity as was done for the other two agencies. However, because the use of digester gas would reduce demand for electricity from the Southern California Edison Plant which would otherwise have been used, this analysis treated the electrical energy equivalent of digester gas produced in the same manner as electricity production. The Orange County Phase II Facilities and Phase III Options were found to result in net production of electrical energy equivalent.

The net electrical energy equivalent (or reduction in electricity demand) for each agency was then compared to the current (1978) and projected (Year 2000) total wastewater treatment system demand. The criterion used in these comparisons, to determine a significantly benefical impact was a reduction in demand of more than 25 percent. Net energy production was then compared to current (1978 or 1978-79) total electricity demand on the electric utility servicing the project. The criterion used to determine significance was a reduction in demand of more than 0.1 percent.

Although energy production for the three proposed plans represented more than 0.1 percent of the total utility system demand, thus meeting the criterion for significance, the significance of the program's benefit to the Region is even more clear when it is realized that this program could contribute to meeting future increases in demand. The latter effect would have the potential to contribute to the forestalling of the requirement for building new power plants. The fact that the energy was produced from a renewable resource rather than petroleum or other nonrenewable resources, also enhances the project's beneficial impacts.

In addition, as a producer of electricity from a source other than nuclear, coal or petroleum-fired power plants, the plans would provide diversity in electrical energy production in the Southern California area, as outlined in California Energy Commission policy and Statewide Energy Strategy.*

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* California Energy Resources Conservation and Development Commission, 1977, California Energy Trends and Choices 1977 Biennial Report of the State Energy Commission; California Energy Commission, 1979, Energy Choices for California - Looking Ahead.

ECONOMIC EVALUATION OF PROPOSED SLUDGE MANAGEMENT PROGRAM

- PUBLIC SECTOR ECONOMY
- PRIVATE SECTOR ECONOMY
- EMPLOYMENT

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APPENDIX C8

ECONOMIC EVALUATION PROPOSED SLUDGE MANAGEMENT PROGRAM

The assumptions and methodology used to assess potential impacts on the public and private sector of the economy and on employment are summarized below.

PUBLIC SECTOR ECONOMY

Impacts on the operating agencies and the populations they serve, were determined by the following methods: (1) Comparing project annual capital and opertions costs to current agency systems costs; (2) computing the project cost per capita (for the population in the service area). The criterion used to determine whether annual cost increase were significant was whether the increase was 25 percent or more of total agency system costs.

PRIVATE SECTOR ECONOMY

A regional input-output model was used to determine the potential impacts on the private sector of the regional economy. The model was used to indicate the impact of capital investment and operational spending on the (1) generation of purchases of supplies and materials and consumer goods in other sectors of the regional economy, (2) increasing output, (3) employment, and (4) household income. The direct and indirect impacts, combined together, would be to the initial purchases of labor and material required for construction and operating expenditures.

Two multipiers from the Southern California Association of Governments (SCAG) Region Input-Output Model* were used to determine impacts of construction investment and operations expenditures: (1) the output multiplier for the general construction sector (2.87 x local spending), and (2) the output multiplier for the electrical, gas, water and sanitation service operations (2.18 x local spending). The output multipliers include output (total dollar).

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* Copley International Corporation. 1979. Overview SCAG Regional Input-Out-put Model.

The determination of the multiplier effect on regional output (as measured by dollar flow) for the long-term was made by applying the operations multiplier (2.18) to the annual operations expenditures.

Short-term construction investment impacts were determined by applying the general construction multiplier to construction investment expended within the region.

The following formula was used for determination of short-term construction investment impacts:

$(.4^{a}\text{x}(\text{Total Capital Cost})+(.6^{b})\text{x}(.75^{c})\text{x}(\text{Total Capital Cost})) \times 2.87 = \text{Total}$

The following assumptions were made:

- Total construction payroll would be spent or saved within the Region, and it represents 40% of total construction costs.*
- Purchase of construction materials and equipment represents 60% of total construction costs.*
- 75% of materials and equipment purchases would be made within Region.**

Total annual operating costs were multiplied, directly by the operations multiplier (2.18).

The criterion used to determine the significance of output generated and induced by implementation of the Program or the alternatives (as measured by dollar flow) was Gross Regional Product for the Los Angeles Metropolitan Area for 1977, $104.7 billion.*** The level of .01 percent of total Gross Regional Product for the Los Angeles Metropolitan Area was used as the test for significance.

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* Personal communication, Peter Bolli, Guy F. Atkinson Company, October 1979, and personal communication, R. Schiada, Connolly-Pacific Company, October 1979

** U.S. Department of Labor. 1974. Consumer Expenditure Survey, 1972-73.

*** Security Pacific National Bank, 1979. The Sixty Mile Circle - The Economy of the Greater Los Angeles Area.

EMPLOYMENT

Construction employment directly related to the program or alternatives was estimated by assuming that total construction cost would be attributable to labor expenses and $50,000 would be expended per person year of labor. Project-generated indirect construction period employment in the retail and service sectors was derived from local expenditures for construction materials and equipment, as well as the construction employment payroll spent locally. Expenditures on construction employment payroll equipment were assumed to be 75 percent local. Construction payroll was assumed to be 60 percent of total labor cost. It was also assumed that 75 percent of payroll would be spent on retail purchases, locally. The criterion used to determine the significance of impacts on construction employment was 0.1 percent of total regional construction industry employment.

The criterion used for permanent employment was 0.01 percent of total regional employment.

Indirect employment generated in the retail and wholesale industries from materials and equipment purchases locally was derived by applying the existing ratio of $50,200 invested per heavy construction job to project construction investment in Los Angeles and Orange Counties. Indirect employment generated in the retail sector from construction payroll was derived by applying the existing ratio of $55,500 of spending per job in the retail industry to retail sales in Los Angeles and Orange Counties.

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